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OF THE

HOUSE OF REPRESENTATIVES

FOR THE

SECOND SESSION OF THE FIFTY-FIRST CONGRESS.

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51ST CONGRESS, 2d Session. } HOUSE OF REPRESENTATIVES. { Ex. Doc. 1, Part 2.

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OF THE

SECRETARY OF WAR;

BEING PART OF

THE MESSAGE AND DOCUMENTS

COMMUNICATED TO THE

TWO HOUSES OF CONGRESS

AT THE

BEGINNING OF THE SECOND SESSION OF THE FIFTY-FIRST CONGRESS.

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O. H. ERNST, Major of ENGINEERS, U. S. A.;
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UNITED STATES ENGINEER OFFICE,
Washington, D. C., July 1, 1890.

GENERAL: I have the honor to forward herewith my annual report for the year ending June 30, 1890, on river and harbor works, etc., in my charge.

Very respectfully, your obedient servant,

PETER C. HAINS,
Lieut. Col., Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

K 1.

IMPROVEMENT OF POTOMAC RIVER AT WASHINGTON, DISTRICT OF COLUMBIA.

Before the improvement commenced the channel to Georgetown was narrow, crooked, and had not sufficient depth to accommodate commerce. Vessels drawing 16 feet frequently grounded at high water above Long Bridge, and to maintain this depth frequent dredging was necessary, and even then the channel was narrow, as the appropriations for dredging were only sufficient to make a narrow cut through the bar.

The Washington Channel was not only shoal, but narrow, and wholly inadequate to the wants of commerce.

The flats in front of the city were large in area, sometimes covered, sometimes not covered, by the water of the river, which was polluted by the sewage of a large city. The sewer at the foot of Seventeenth street discharged its contents on the flats, rendering some parts of the city in that vicinity almost uninhabitable. By act passed August 2, 1882, Congress adopted a project which had for its object the improvement of the navigation of the river by widening and deepening its channels; the establishment of harbor-lines, beyond which no obstructions should be built; and at the same time the filling of the flats or marshes on the city front, so that they would not be overflowed, the material to be dredged from the channels to be used in filling the flats. The project provides for such depth of channels as will accommodate the largest class of vessels that can reach Arsenal Point, with such additional depth at the wharves as will enable vessels to receive full cargoes without grounding at low water; for filling the flats above Long Bridge to a height of 3 feet above the flood-line of 1877 and the middle part of the flats below Long Bridge to the same height, sloping to 6 feet above mean low tide at the margin; that in order to purify the water of the Washington Channel, which will be cut off at the upper end from the Virginia Channel, a tidal reservoir or basin be established between the sewer-canal and Long Bridge, to be filled with water from the Virginia Channel on the flood tide and discharged into the Washington Channel on the ebb. The plan also contemplates the rebuilding of Long Bridge with longer spans during the progress of the work, and the interception of all sewage now discharged into the Washington Channel and its conveyance to the James Creek, but neither the reconstruction of the bridge nor the building of the intercepting sewer were included in the estimated cost of the improvement.

The estimated cost of the improvement is $2,716,365.

The appropriations made for the work are as follows:

By act of August 2, 1882	$400,000
By act of July 5, 1884	500,000
By act of August 5, 1886	375,000
By act of August 11, 1888	300,000
Total	1,575,000

The amount expended up to the close of the fiscal year ending June 30, 1889, is $1,423,764, or somewhat more than one-half the original estimate for the entire work. The following work has been accomplished: The Virginia Channel above Long Bridge has been deepened to 20 feet for a width of from 400 to 550 feet, a part of which has filled up since and been redredged. The same channel below Long Bridge has been dredged to a depth of 20 feet and a width of about 350 feet. This part of the Virginia Channel has maintained itself to the full depth originally dredged or has deepened. The Washington Channel has been dredged to a depth of 20 feet for a width of 350 feet throughout its entire length, and from the Seventh Street Wharf to its junction with the main channel to a depth of 12 feet for a width of from 100 to 250 feet.

This channel has for the most part maintained itself to the full depth dredged, though some filling took place in the freshet of June, 1889.

There has been dredged from the channels of the river and from the area of the tidal reservoir about 8,301,000 cubic yards of material, chiefly mud and sand, all of which has been deposited on the flats, raising them above overflow by ordinary high tides over almost the entire

POTOMAC RIVER
AT
WASHINGTON, D. C.

MAP SHOWING PROGRESS OF WORK
JUNE 30, 1890.

Scale:

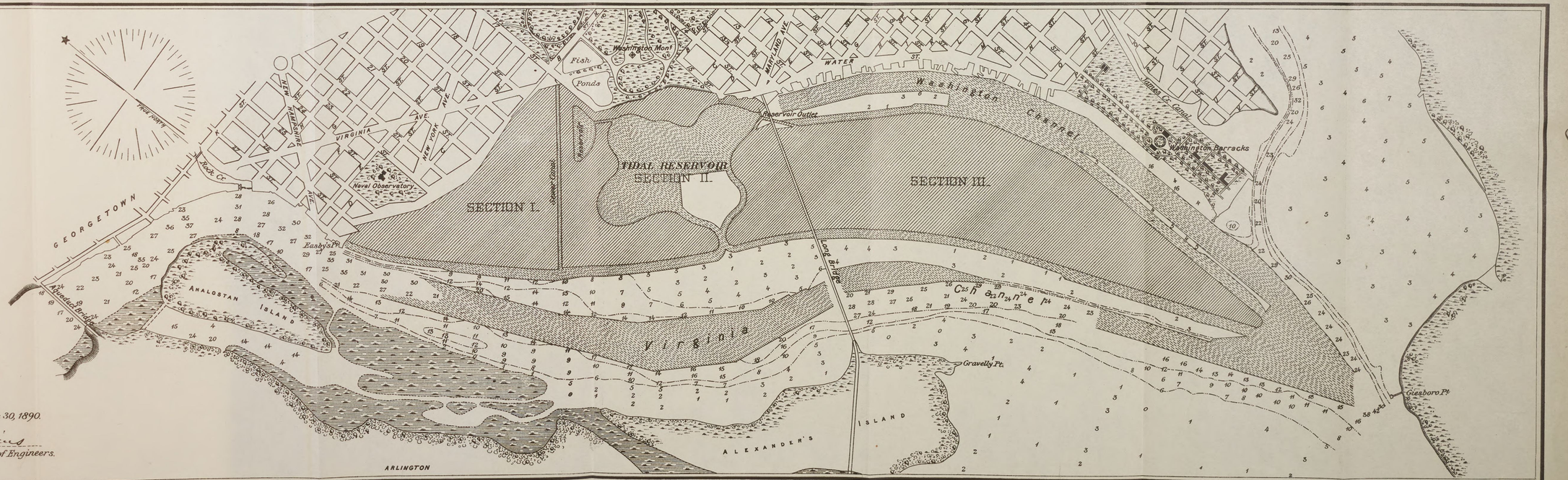
500 0 500 1500 2500'

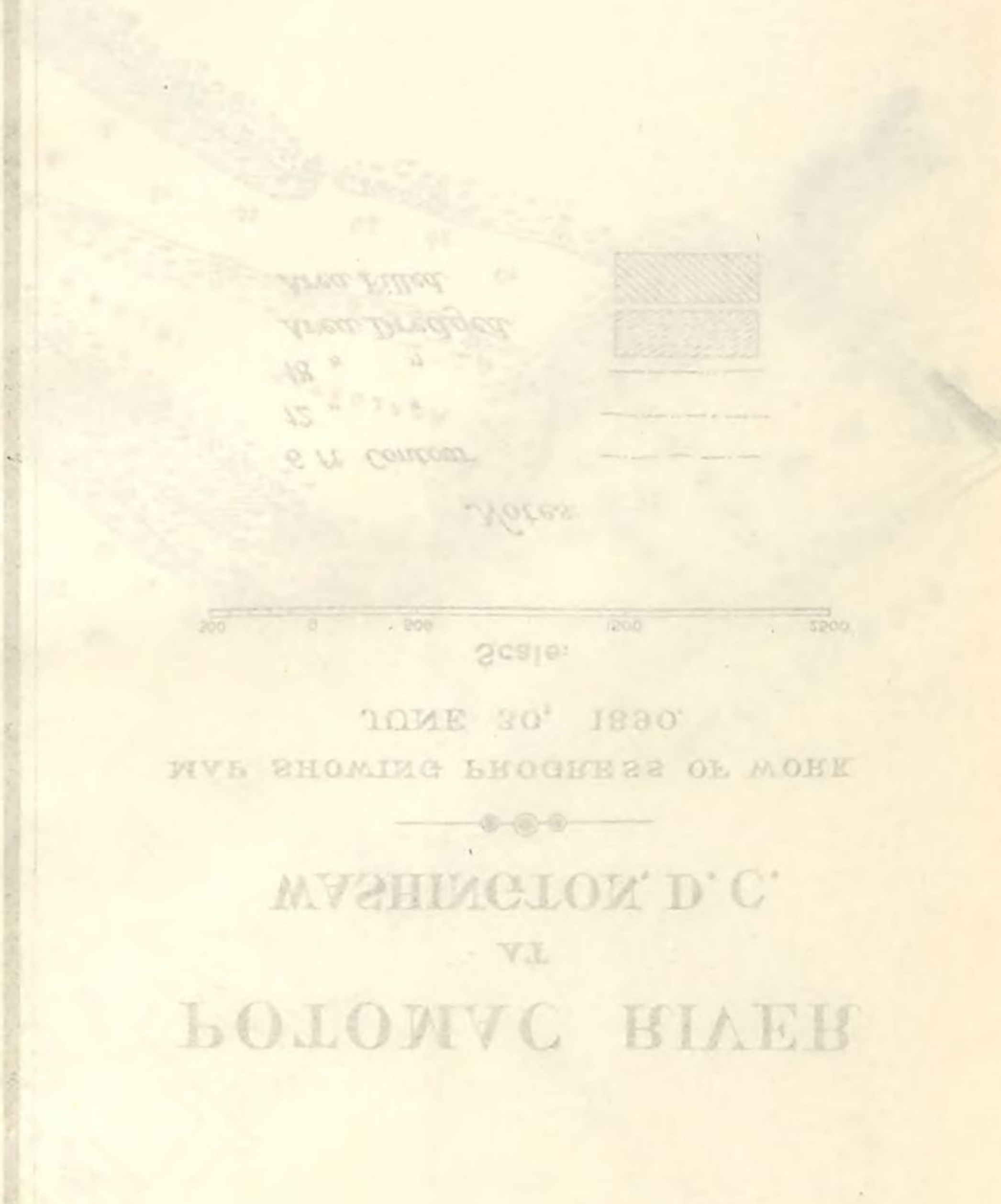
Notes:

6 ft Contour
12 " "
18 " "
Area Dredged.
Area Filled.

To accompany Annual Report of June 30, 1890.

Lieut. Colonel of Engineers.




Scale:
200 0 400 1200 2000

area of 621 acres, and some of it to a much higher grade, thus creating an area of magnificent parking land where formerly there existed pestilential marshes. Independent of the benefits to navigation or the incidental benefit to the health of the city, the value of this land is estimated to be far in excess of the cost.

The amount expended during the past year has been $137,941.50. This sum was devoted to completing certain dredging in the Washington Channel, raising some of the embankments along the outer margin of the flats, protecting to some extent the embankments thus formed, constructing the reservoir outlet and other work incidental to carrying on an extensive improvement of this character. It is proper to remark that the work has suffered from lack of sufficient money to prosecute it with more vigor. If funds had been more liberally provided a much larger amount of work would have been accomplished at a still lower proportional cost. The work has been practically at a stand for nearly a year.

There were three hydraulic dredges engaged on this work at one time, having a united capacity, under favorable conditions, of nearly 10,000 cubic yards per day. They have all been withdrawn. It will not be easy to get them back again. Such machines, to accomplish economical work, must have a sufficient amount in sight to keep them occupied for a long time. They are expensive tools to keep unemployed. One hydraulic machine was kept in operation dredging the Washington Channel and filling Section III until February 19, 1890, when the contract of the California Hydraulic Dredging and Reclamation Company was completed.

Comparatively little work was done during the year ending June 30, 1890, no appropriation having been made the previous year. The masonry of the reservoir outlet was completed up to within one course on the head-walls and the coping during December of 1889 and the gates put in place. The removal of the coffer-dam was completed by about the middle of March, 1890. The gates work very satisfactorily.

The dredged Virginia Channel above Long Bridge had filled up to a considerable extent during the subsidence of the freshet of June, 1889, so that not more than about 17 feet could be carried over the bar at high tide. Bids were accordingly invited for dredging a cut about 130 feet wide and not less than 21 feet deep at high tide through it. The work was advertised, but the lowest bid, that of Thomas P. Morgan, at 24 cents per cubic yard, was regarded as too high. The bids were rejected, and the contract subsequently awarded to Frank C. Somers at 20 cents per cubic yard. The material is dredged from the channel and placed in scows, which are towed to the margin of the fill and dumped. It is then redredged and placed in the embankment. This work is now about completed, and leaves us with an available balance of only $5,184.72.

The importance of an early appropriation of about $500,000 is strongly felt. The work that has been done, and which has cost about one and one-half millions, should be put in a condition of safety against damage by freshets. From a business point of view this is urgently demanded. The dredging in the Washington Channel is now nearly finished. It is deep, and for the most part wide and commodious. A single freshet is apt to damage it immensely. The amount of material that can be washed into it, scattered over a large space, will necessitate expensive dredging to remove. The embankments around the margin of the fill, to retain the material placed on the flats, have now been raised to a considerable height. They are constantly being eroded by the

waves and need frequent expenditures to maintain them. They should be protected by a revetment of stone. It would be an economical measure for Congress to make a single appropriation of about $500.000, which could be applied in such a way as to protect what has already been accomplished. Subsequent appropriations could then be made more leisurely and without danger to the work done.

LONG BRIDGE.

The necessity for early action in regard to the reconstruction of Long Bridge has been referred to in my Annual Reports for the last eight years. It is now imperative that this work should be no longer delayed if the destruction of the bridge itself, as well as damage to the work on the river front and still greater damage to the city, is not to be invited. The Government bas expended $1,500,000 in improving the navigation and raising the flats. While Long Bridge remains as it is the work on the channel above it must be done over and over again. The trouble is not that there is a bridge at this place. It is because of the faulty construction of the bridge. As stated in former reports, the spans are short, the piers too numerous and set in positions that make them more obstructive to the flow of the water than they need be. Besides, they are built on pile and grillage foundations which reach about to the level of low water and require enrockments, or mounds of stone, around them to secure and keep the material composing the bed of the river from being washed away. The accompanying sheet will illustrate the existing conditions. As the bridge will be used both by the railroads and by the public generally, it would seem to be only fair that the Government should pay one-half the cost of its reconstruction.

By Department indorsement of March 10, 1890, I was directed to report upon Senate resolution of March 7, 1890, requesting the Secretary of War to investigate the desirability of separating the wagon-road from the railroad on that portion of Long Bridge between the north side of the Virginia Channel and the foot of Maryland avenue. A copy of my report, made under date of April 2, 1890, is appended.

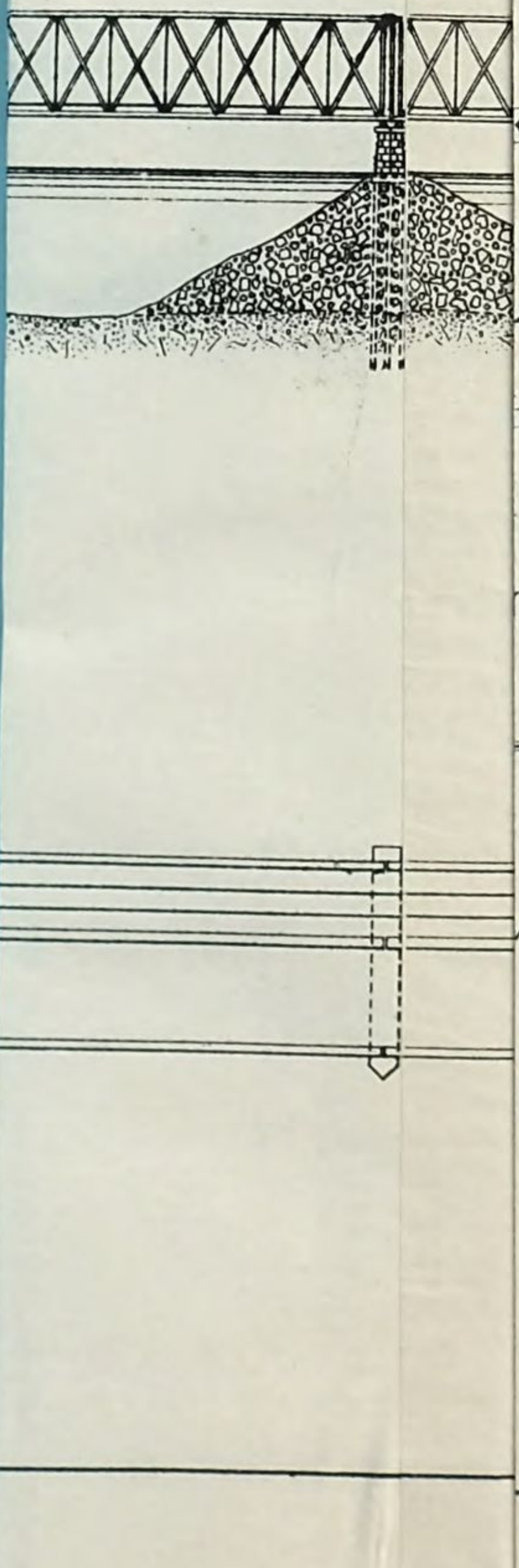
Amount expended on the improvement up to and including June 30, 1890	$1,561,705.50
Amount required to complete the improvement	1,141,365.00
Annual cost of preserving and maintaining (estimated)	5,000.00

Washington City is in the collection district of Georgetown, D. C.; nearest lighthouse, Jones' Point, Virginia.

Money statement.

July 1, 1890, amount available		$52,303.74
July 1, 1889, amount covered by existing contracts		81,743.39
		134,047.13
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$120,752.63	
July 1, 1890, outstanding liabilities	1,565.58	
July 1, 1890, amount covered by uncompleted contracts made during the fiscal year ending June 30, 1890	6,544.20	
		128,862.41
July 1, 1890, balance available		5,184.72
Amount appropriated by act of September 19, 1890		280,000.00
Amonnt available for fiscal year ending June 30, 1891		285,184.72
Amonnt (estimated) required for completion of existing project		861,365.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		800,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.



ECTION

of

AC RIVER

H THE AXIS OF

BRIDGE

E 30, 1890.

Scale

50 100 150 FT.

nual report of June 30, 1890.

Lieut. Colonel of Engineers

Abstract of proposals for dredging in the Virginia Channel of the Potomac River at Washington, D. C., opened December 30, 1889, by Lieut. Col. Peter C. Hains, Corps of Engineers, U. S. Army.

[Estimated quantity, 75,000 cubic yards.]

No.	Name and address of bidder.	Price per cubic yard.	Amount.	Commence.	Dredge monthly.	Complete.
		Cents.			*Cu. yards.*	
1*	Daniel McConville, Washington, D. C.	25	$18,750	Mar. 1, 1890	20,000	June 30, 1890
2†	Thos. P. Morgan, Washington, D. C ..	24	18,000	....do	22,000	Do.

*Proposed to use two clam-shell dredges in channel and an endless-chain dredge at bank.
† Proposed to use two clam-shell dredges and an endless-chain dredge or chute.

Both bids were rejected. Frank C. Somers, of Camden, N. J., afterwards made a proposition to do the work for 20 cents per cubic yard, which was accepted and contract made January 21, 1890.

Abstract of contracts for improving Potomac River in the vicinity of Washington, D. C., in force during the fiscal year ending June 30, 1890.

No.	Name and address of contractor.	Date of contract.	Subject of contract.	Price.
1*	D. L. Shoemaker, Washington, D. C ...	Mar. 3, 1888	Broken stone ...	$1.55 per cubic yard; $1.40 per cubic yard.
2*	E. E. Burrough, Washington, D. C.....	....do	Sand.....	75 cents per cubic yard.
			Pebbles	$1.20 per cubic yard.
3*	Henry Wilson, Washington, D. C	Oct. 23, 1888	Dredging	11½ cents per cubic yard.
4*	California Hydraulic Dredging and Reclamation Company, San Francisco, Cal.	Oct. 27, 1888	... do	12½ cents per cubic yard.
5*	James H. McGill, Washington, D. C ...	July 25, 1889	Cement.....	$2.34 per barrel.
6	Frank C. Somers, Camden, N. J	Jan. 21, 1890	Dredging	20 cents per cubic yard.

*Completed.

COMMERCIAL STATISTICS.

Receipts and shipments.

Years.	Coal.	Ice.	Lumber.	Sand.	Wood.	Miscellaneous.	Total.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1887	264,947	120,237	37,044	50,000	52,419	94,325	618,972
1888	240,836	108,421	45,101	50,000	33,040	104,177	581,575
1889	*92,511	115,506	41,407	75,000	35,351	128,905	488,680

*The falling off in coal is due to the destruction of the Chesapeake and Ohio Canal.

Number of vessels of various classes arriving and departing.

Years.	Steamers drawing from 5 to 15 feet, 100 to 400 tons.	Vessels drawing from 10 to 18 feet, 300 to 1,500 tons.	Vessels drawing from 4 to 10 feet, 30 to 300 tons.	Barges drawing from 4 to 10 feet, 100 to 300 tons.
1887.....	970	573	2,149	993
1888.....	710	525	1,588	2,821
1889.....	675	455	1,563	929

Ferry and local passenger steamers are not included in the above.
No new lines of transportation were established during 1889.

SPECIAL REPORT ON SEPARATING WAGON-ROAD FROM RAILROAD ON THE NORTH SIDE OF MAIN CHANNEL OF POTOMAC RIVER.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., April 2, 1890.

GENERAL: By indorsement of March 10, 1890, Office Chief of Engineers, the following resolution of the Senate of the United States was referred to me for report:

IN THE SENATE OF THE UNITED STATES,
March 7, 1890.

Resolved, That the Secretary of War be requested to investigate, in connection with the Potomac flats improvement, the desirability of separating the wagon-road from the railroad on the north side of the main channel of the Potomac, and to furnish an estimate of the cost of the same.

Attest: ANSON G. McCOOK,
Secretary.

In obedience to your orders I have to report as follows: The main channel of the Potomac is that one between the outer margin of the Potomac flats improvement and the Virginia shore and is commonly known as the Virginia Channel. From the north side of said channel, as well as across it, to the south end of Maryland avenue, the Baltimore and Potomac Railroad tracks and the public wagon-road are on the same bridge and necessarily close together. It is presumably to the separation of these on the north side of the channel that the resolution of the Senate of the United States refers.

Long Bridge was first built in 1809 by the Washington Bridge Company, and the act of Congress, February 5, 1808, which authorized its construction, authorized the collection of tolls. At that time there was no causeway between the Washington Channel and the main or Virginia channel, as there is now. In 1831 the bridge was destroyed by a freshet. In 1834 an appropriation was made to rebuild it and it was rebuilt. In 1840 it was again partially destroyed by a freshet and the sudden breaking up of ice. In 1843 it was repaired and again opened for travel. In 1870 the Baltimore and Potomac Railroad Company was authorized to take possession of, and extend its tracks across, the bridge (see act approved June 21, 1870), under the following conditions to wit:

Provided, That the said Baltimore and Potomac Railroad Company will maintain in good condition the said bridge for railway and ordinary travel; and the bridge shall at all times be and remain a free bridge for public use for ordinary travel.

* * * * * * *

That if the said Baltimore and Potomac Railroad Company shall at any time neglect to keep said bridge in good repair and free for public use for ordinary travel the Government of the United States may enter into possession of the said bridge; and Congress reserves the right to alter or amend this law.

The bridge remains to-day the property of the Baltimore and Potomac Railroad Company by virtue of that act of Congress. By the term bridge is meant the entire structure from the Washington shore to the Virginia shore, including the causeway across the flats. The total length of the bridge, inclusive of the causeway, is 4,677 feet. The railroad is a single-track road. The wagon road is close alongside of it the entire distance.

The bridge was badly damaged by the freshet of last June, and it has been necessary to support that part between the Fourteenth street abutment and the north end of the causeway by trestles.

At one place on the bridge there is barely width enough for a single wagon and a single train of cars to pass. In its present condition it is

far from being a convenient structure, and the separation of the wagon road from the railroad, so that one would be entirely independent of the other, would be an improvement over the existing arrangement. Indeed, a wagon road and a railroad on one and the same bridge is always objectionable and is only tolerated from necessity. The portion of the bridge that spans the Washington channel is now in such a condition that the question of rebuilding it entirely, rather than repairing it, is one for serious consideration, from motives of economy.

It may be assumed that there will always exist a necessity for a bridge at or in close proximity to the existing bridge; that it will be needed for railroad and ordinary traffic; that the traffic of both kinds over it will increase from year to year.

Under the circumstances, and in view of its present condition and of the improvements now being made by the Government on the river front, it would seem that it is desirable to separate the wagon road from the railroad, provided their separation be made in accordance with some comprehensive plan of improvement that is ultimately aimed at for this particular locality, and in which the railroad company and the Government are both so vitally interested.

The first thing then to determine is, what should be the project aimed at? The Government has already expended over a million of dollars in improving the river front by filling up the marshes or flats and digging out channels for the accommodation of commerce. It has created an area of 650 acres of land above overflow by ordinary tides where formerly there existed acres of pestilential marshes. The land thus made, though not yet raised to the full height intended, already assumes a value estimated as in excess of its cost and is susceptible of being made into one of the finest parks in the District. This land is cut in two by the causeway portion of the bridge, and, should the Government decide to utilize it as a park, it is of supreme importance that the railroad tracks be carried over it on a grade that will allow free communication beneath them. To keep the railroad on the grade of the park would be decidedly objectionable.

Again, that part of Long Bridge that spans the main channel of the river is, as now built, a serious obstruction to the free flow of the river in times of freshets. The Board of Engineers that recommended the plan of improving the river front, now being carried out, called attention to the necessity of rebuilding that structure with wider spans at an early stage of the work. The freshet of June last emphasized it. Reports have frequently been made to Congress calling attention to the matter. Had the freshet of last June occurred when the river was full of ice a gorge would most probably have formed at the bridge and destroyed it. At the same time a much larger area of the city would have been inundated.

There is no possible way of preventing freshets. Moreover, they are most apt to occur when the ice in the upper Potomac breaks up after heavy rains.

Long Bridge has been at least partially destroyed several times already. When there is a freshet in the river ample room should be given to allow the water to flow off freely. If it be partially dammed up as it now is, by the Long Bridge as constructed, the level will be raised and the chances of the water being thrown in on the city increased.

The reconstruction of Long Bridge over the main channel of the river forms an essential part of any project that looks to the permanent improvement of the river front, and is intimately connected with the ques-

tion of separating the wagon road from the railroad on the north side of that channel.

In reply, therefore, to the inquiry of the Senate of the United States I would say that the separation of the wagon road from the railroad on the north side of the main channel of the Potomac would be desirable as a part of a project that looks to the raising of the grade of the railroad tracks across the flats high enough to give passage-way for vehicles under them, and to the reconstruction of the bridge over the main channel of the river on wider spans, that will cause less obstruction to the flow of the water.

The project, stated in few words, would be somewhat as follows:

At or near the intersection of Maryland avenue and Thirteen-and-a-half street, where the grade of the street is 24 feet above mean low tide in the Potomac, carry the railroad tracks with a rising grade southward, over a viaduct of brick masonry with arched openings or on iron trestles (so as to allow communication under the tracks), to a point marked A on the accompanying tracing. From this point to B, a distance of about 180 feet, the head of the Washington channel to be spanned by two arched trusses or plate girders, which should rest on new abutments and one new pier, that would not materially obstruct the flow of water from the tidal reservoir into the Washington channel. From B the railroad to be carried on a brick-arched viaduct, or on iron trestles, at such grade (about 28 feet above the plane of mean low tide) as would allow free communication under it to C. From C the grade of the railroad to be 1 foot in 100 feet till it reaches, at D, the north abutment of a new bridge across the main channel of the river, or, better still, the grade could be carried at 28 feet to said abutment. The wagon road, starting from the foot of Fourteenth street, to cross the upper end of the Washington channel on a separate and distinct bridge from that which will carry the railroad, run nearly parallel to the latter, but some distance from it, till it reaches the new bridge across the main channel. This new bridge should be constructed on the west side of the existing bridge, arranged for a double-track railway, and wagon road, to have eight spans of about 270 feet each, with a pivot-draw in the deep water of the channel. The depth of water between the piers to be deepened to about 10 feet on the shoal part of the river, to give ample sectional area for freshet discharge. As soon as the new bridge is constructed, the old one, with its piers and about 400 feet of the causeway at the south end, to be removed.

Such a project, if carried out, would enable uninterrupted communication to be maintained over the lands of the Government, whatever they be used for, and would enable a railroad and wagon crossing of the Potomac to be maintained at this locality with the least practicable obstruction to the flow of the water of the river.

The cost of the entire project is roughly estimated at about $1,250,000.

If, therefore, the wagon road be separated from the railroad on the north side of the main channel as a part of and in conformity to such a general project, or one of a similar nature, there can be no question but that it is desirable.

To build a new wagon road from the foot of Fourteenth street across the Government lands to the north end of the existing bridge, across the main channel of the river, inclusive of a new bridge across the head of the Washington channel, would cost about $75,000.

I transmit herewith a blue print* of the map that accompanied my

*Omitted; printed in Senate Ex. Doc. No. 96, Fifty-first Congress, first session.

annual report for the year ending June 30, 1889, showing the progress of the work on the flats; also two tracings,* viz: "A plan of Long Bridge, showing how the wagon road and railroad can be separated on the north side of main channel of Potomac River" and "Profile of new bridge across the Potomac River, proposed as a substitute for the existing Long Bridge."

Very respectfully, your obedient servant,

PETER C. HAINS,
Lieut. Col., Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

SPECIAL REPORT IN REGARD TO MOST SUITABLE KIND OF BRIDGE FROM FOOT OF NEW YORK AVENUE ACROSS THE POTOMAC RIVER TO ARLINGTON.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., April 17, 1890.

GENERAL: By indorsement of the Chief of Engineers, dated February 21, 1890, the following resolution of the Senate of the United States was referred to me for report:

IN THE SENATE OF THE UNITED STATES,
February 20, 1890.

Resolved, That the Secretary of War be, and he is hereby, directed to examine and report to the Senate on the most suitable kind of bridge with approaches from a point at or near the foot of New York avenue, across the Potomac River, to a point on the United States National Cemetery grounds at Arlington, so as to connect in the best manner the public grounds on both sides of the Potomac River, with estimates of the kind of bridge deemed most expedient and which will not interfere with the navigation of said river.

Attest:

ANSON G. McCOOK,
Secretary.
By CHAS. W. JOHNSON,
Chief Clerk.

In obedience to your orders, I have to report as follows:

That a bridge of some kind, to connect the public lands on the two sides of the Potomac, is urgently needed, scarcely admits of argument. The only question is, what is the most suitable kind of a structure, and what the most eligible location.

The most suitable kind of a bridge is one that will afford easy and safe passage for vehicles and pedestrians, and at the same time not materially obstruct navigation. How this can best be accomplished is a matter on which there may be some diversity of opinion. Any bridge that does not give a clearance under it of at least 150 feet to the water, would be more or less an obstruction. Schooners are now built for coasting and foreign trade that have masts reaching to a height of nearly 150 feet from the water-line. Such a schooner came to this port only a short time ago. It was 148 feet from the water-line to the top of her top-masts; the latter were 50 feet long, but she could unship and lower them without difficulty. Even then, however, she required 98 feet clearance. The schooner was four-masted, but this is a type of vessel that is rapidly coming into general use in this country. To require a vessel when she comes into port to lower her top-masts is regarded as objectionable by the shipping interests; but when the bridge is low it

*Omitted; printed in Senate Ex. Doc. No. 96, Fifty-first Congress, first session.

can be avoided only by providing a draw. This, however, will sometimes get out of order, particularly if not in frequent use; at other times it is a nuisance to the public, for when open travel is obstructed.

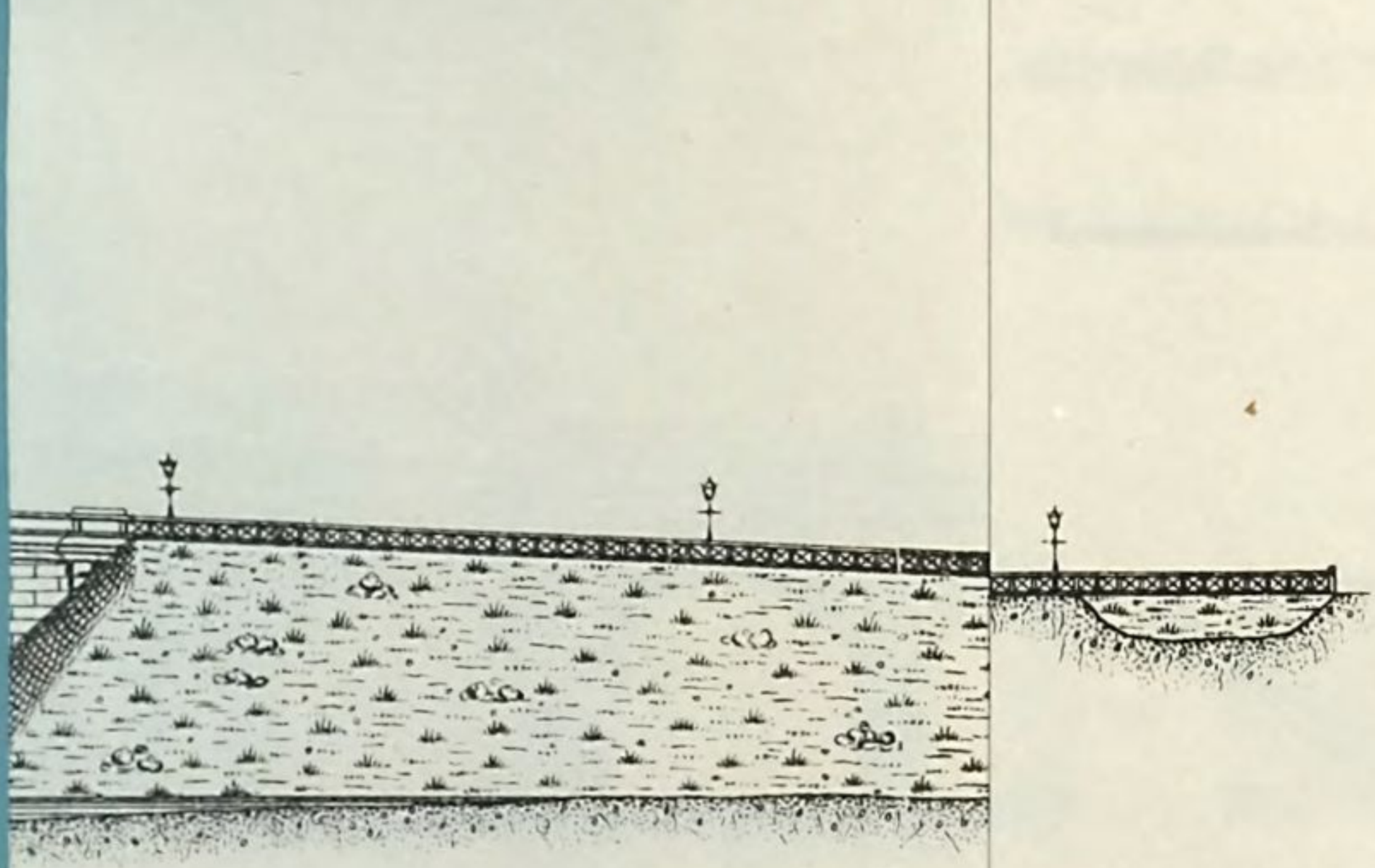
As to location, a glance at the tracing transmitted herewith can not fail to convince any one that the line of New York avenue extended, or one very near it, is by far the most desirable, providing no extraordinary engineering difficulties are to be met on that line. There are about 1,056 acres of land in the Arlington property. The Potomac Flats and the connected public grounds west of, and including the Capitol, contain about 1,120 acres more. The approaches on each end will be on Government land, so that land damages will not increase the cost or cause litigation. The position is about midway between the Long Bridge and the Aqueduct Bridge. It is the shortest route from any point along the shore line of the District to the Arlington cemetery. It is believed that there are no engineering difficulties in the way.

In this connection I would respectfully call attention to the report I submitted June 21, 1886, in response to Senate resolution of May 24 of that year, calling on the Secretary of War for a report on the expediency of constructing a Government bridge, *with a suitable draw* and approaches, at or near the foot of New York avenue or New Hampshire avenue. In that report I submitted plans of a draw-bridge, with a roadway of 24 feet, and two side walks of 8 feet each, giving a clearance of 24 feet from the surface of the water to the lowest member of the bridge. Such a bridge would not seriously obstruct navigation, and it would cost only about $600,000.

The last resolution of the Senate, however, calls for the *most suitable* kind of a bridge to connect *in the best manner* the public grounds on both sides of the Potomac. It may be seriously questioned whether any draw-bridge is suitable for this locality. Public sentiment seems to demand something better than a cheap, substantial structure, built for utility alone. A bridge built with a clear height above the water of 150 feet, which is the only kind that would not in some degree obstruct navigation, is out of the question on account of its great cost and the steep grades that it would necessitate in the approaches. A bridge with a draw is not one that meets the requirements. Under the circumstances it would seem only reasonable that the commercial interests should yield something to the public needs, and the latter should impose no unnecessary obstacles to navigation. A fair compromise would seem to be a bridge without a draw, yet high enough to allow almost any vessel to pass under by lowering her top-masts. The lowering of the top-masts of the largest vessels would not be an unreasonable concession to the public, for it is only at rare intervals that such vessels make their appearance in this harbor. The vast majority of vessels could pass under it freely, without even that inconvenience.

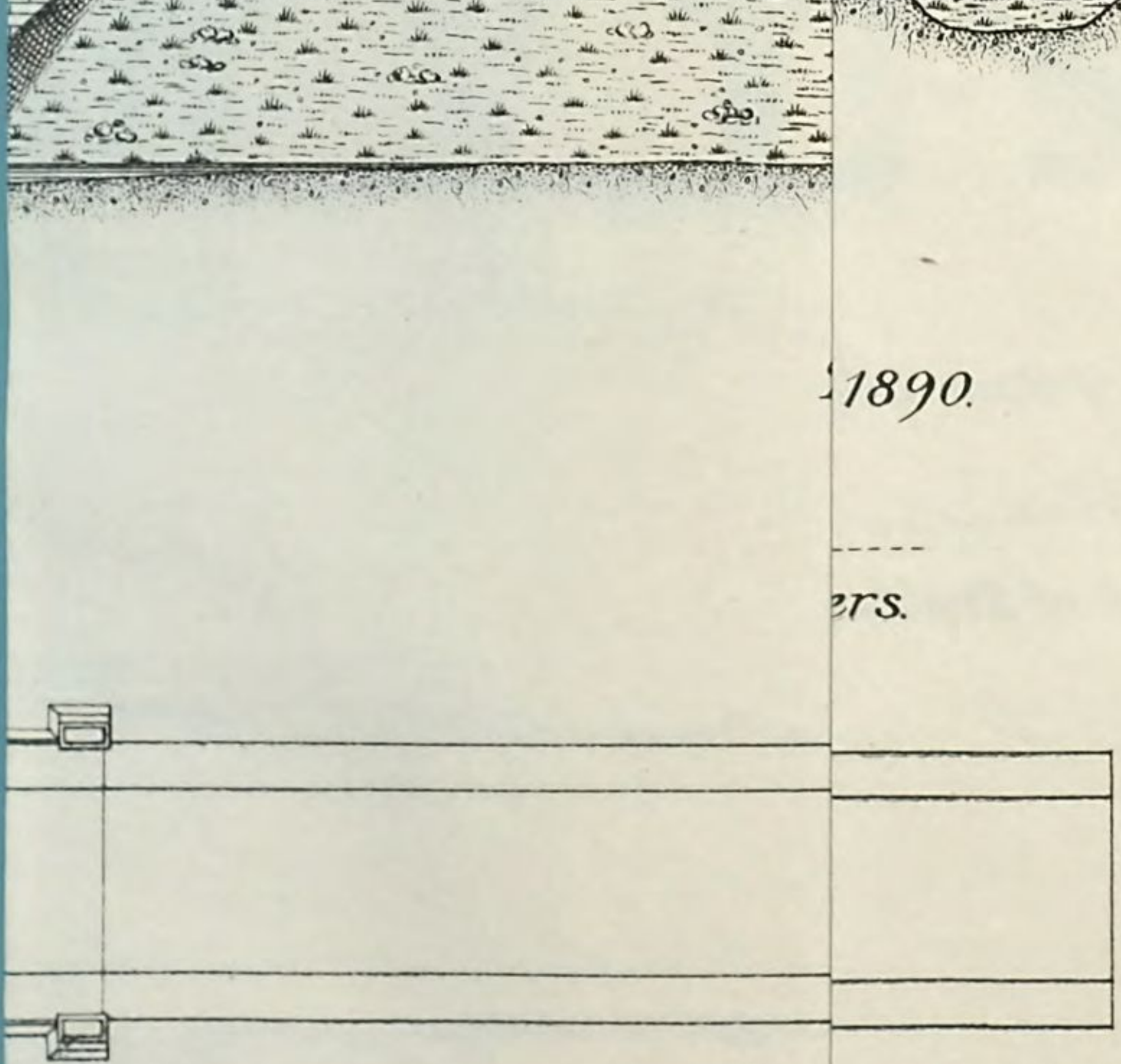
With a view to meeting the objections to a draw-bridge, and at the same time to bring the cost of one without a draw within reasonable limits, I have designed a bridge on the suspension principle, the clear height above the water at mid-channel to be 105 feet; the river span to be 1,100 feet, and two shore spans 652 feet each; the approaches at each end to be on masonry-arched viaducts and embankments of earth; the suspension-cables to be of steel, passing over two granite towers, each about 210 feet high, pierced with arched openings for roadways, and anchored into masses of masonry at the outer end of each approach. The grades to be 3 feet per 100 on the central span, 3.5 on the shore spans, and 4 feet per 100 on the approaches. The extreme width of bridge to be about 54 feet, with a roadway for vehicles 34 feet wide in

SGE



1890.

ers.



Total	4580 ft.
Distatre of Span	105 "
Rive	1100 "
Width	34 "
"	16 "



the clear, and two sidewalks for pedestrians 8 feet each. Lateral vibration would be prevented by a system of ties extending out from the sides of the towers, and vertical vibration by means of the four trusses.

The clear height of 105 feet above water-level will allow the largest four-masted schooners to reach Georgetown by lowering their top-masts, while the span of 1,100 feet practically leaves the full width of the river unobstructed both to navigation and to the free flow of the waters of the Potomac.

It is not to be understood that the plan and elevation submitted are designed as finished working drawings. There are many details of construction and architectural features that would require to be elaborated, and no attempt has been made in the accompanying drawings to do this in any other than a general way.

The drawings are designed to show the general character of such a structure, its outlines, general effects, and to enable an approximate estimate to be made of the cost.

Such a bridge as I have indicated is, in my opinion, the most suitable kind of a structure to connect the public lands on both sides of the Potomac River.

The estimated cost is as follows:

APPROXIMATE ESTIMATE OF THE COST OF A SUSPENSION-BRIDGE ACROSS THE POTOMAC RIVER, ON THE LINE OF NEW YORK AVENUE (EXTENDED), FROM THE NAVAL OBSERVATORY GROUNDS TO ARLINGTON.

Bridge to have one central span of 1,100 feet, two land spans or 652 feet each, with approaches of masonry and earth embankment. Bridge to be 54 feet wide, with roadway of 34 feet, and two sidewalks of 8 feet each. Live load, 70 pounds per square foot. Approaches, 60 feet wide.

East approach :	
Embankment with masonry walls	$19,000
Masonry arches	232,000
East anchorage	424,000
East tower	392,000
Suspended superstructure	623,000
West tower	404,000
West anchorage	521,000
West approach :	
Masonry arches	395,000
Embankment	81,000
Contingencies	500,000
Total	$3,591,000

By reducing the width to 40 feet, making the roadway 24 feet wide instead of 34, a reduction of $500,000 can be made in the estimated cost. A still further reduction of about $400,000 could be made by building the approaches on iron trusses, resting on masonry piers. It is proper to add that these modifications would detract from the dignity of the structure, and would not harmonize with the architectural features of other parts of the work.

I inclose herewith two tracings, viz: A map* of the public lands on both sides of the Potomac River, showing also the proposed line of the bridge and a plan and elevation for a suspension-bridge on the line indicated.

Very respectfully, your obedient servant,

PETER C. HAINS,
Lieut. Col., Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

* Omitted.

K 2.

BRIDGE ACROSS THE EASTERN BRANCH OF THE POTOMAC RIVER, DISTRICT OF COLUMBIA.

The construction of a bridge across the Eastern Branch of the Potomac River at the foot of Pennsylvania avenue southeast, in the District of Columbia, was authorized by act of Congress approved February 23, 1887. The act provided for the construction of a "substantial wooden, iron, or masonry bridge," and appropriated the sum of $110,000 therefor.

Under date of September 20, 1887, a contract was entered into with the Groton Bridge and Manufacturing Company of Groton, N. Y., for the construction of the bridge contemplated by the above act, at a total price of $105,000. The location of the bridge was fixed on a line making an angle of about 6° with the extension of Pennsylvania avenue, the width of the bridge to be 32 feet, and the grade of the roadway to be 35 feet above low tide in the river. The contract provided that the bridge should be of iron, resting on masonry piers, and should consist of one through span of 90 feet, over the tracks of the Baltimore and Potomac Railroad, eleven deck spans of 112 feet each, and an earthen embankment of 680 feet.

Work at the site of the bridge was actually begun on October 19, 1887, but had not proceeded far when a difficulty arose with the Baltimore and Potomac Railroad Company, which was the source of much delay. The original plans provided for crossing the railroad by means of a 90-foot through span at the extreme westerly end of the bridge. The contractors had hardly commenced the excavation for the foundation of the western abutment when they were forcibly interfered with, during November of 1887, by officials of the railroad company who declared that the abutment would not be allowed to be constructed upon the site selected. The railroad people claimed that they were entitled to a right of way of 66 feet, measured 33 feet on each side of the center line of the existing tracks, and that the abutment, if constructed as proposed, would encroach upon that right of way. On behalf of the Government it was claimed that a width of way of 66 feet had been allowed (though not measured 33 feet on each side of the center line of tracks), that the tracks were upon a Government reservation over which no such right of way had ever been granted, and that the railroad was not located upon the line by which it was authorized by law to enter the city of Washington, but at a distance of nearly 200 feet from the proper line. A suit was instituted under the direction of the Attorney-General to obtain an injunction to restrain the railroad company from further interfering with the work. The matter had not been adjusted when Congress, by act approved May 14, 1888, made an additional appropriation of $60,000, and authorized the Secretary of War to make such alterations in the plans of the bridge as would best accommodate traffic over and under it, and provided that the Baltimore and Potomac Railroad Company should pay their fair and just proportion of the cost of said alteration at the west end of the bridge. During July, 1888, the matter was settled by making such changes in the plans as to provide for the erection of two through spans of 151 feet each at the west end of the bridge, in place of one 90-foot through span and two 112-foot deck spans, as originally designed. Under date of July 26, 1888, a supplemental agreement was made with the contractors, providing for the above changes, at an additional price of $40,000 over and above the original contract price.

Work on the amended plans was commenced, and at the close of the fiscal year 1889 nine deck-spans had been erected, the eastern abutment

completed, and the western one nearly completed. The eastern approach had been nearly completed, the material for the 151-foot through spans was in course of preparation, and work was well advanced on the foundations of the piers designed to support the through-spans. The foundations for these piers (designated for convenience of reference as piers A and B) gave the contractors considerable trouble. The terms of the supplemental agreement of July 26, 1888, required the construction of coffer-dams inclosing the foundations of piers A and B, from which all soft material was to be excavated to a depth of 16 feet below low tide, the space to be filled in with riprap, stone, and gravel. From motives of economy the contractors adopted a circular form of coffer-dam. Each dam failed twice, and it was about the middle of August, 1889, before the masonry of the piers could be commenced. Most of the stone had been quarried and cut at the Seneca quarries, on the Chesapeake and Ohio Canal. The canal was destroyed by the freshet of June 2, 1889, and the contractors were obliged to haul the material across the country in wagons to a station on the Baltimore and Ohio Railroad, shipping it from thence to Washington by rail. This caused more delay.

The work of laying the flooring on the deck-spans was commenced about the last of August, 1889. The erection of the 151-foot through-spans was commenced on January 20, 1890. The bridge was opened to public travel on March 20, 1890.

Upon the completion of the contract of the Groton Bridge and Manufacturing Company there remained an unexpended balance of about $14,000, which was applied to certain additional work not covered by the contract of the Groton Company, but which was necessary to better accommodate traffic over and under the bridge. These included the placing of additional riprap protection around some of the piers, painting the under side of the through-spans with asbestos paint, paving the embankment slopes, construction of a watchman's house, plank walk, gutters, etc. Plans and specifications were prepared and bids were opened on April 4, 1890. Contracts were awarded to William Rothwell and W. H. Mohler, both of Washington, D. C., as per the accompanying abstracts. The work under both contracts is now completed.

Money statement.

July 1, 1889, amount available		$15,846.76
July 1, 1889, amount covered by existing contracts		80,455.56
		96,302.32
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$88,133.93	
July 1, 1890, outstanding liabilities	7,157.03	
		95,290.96
July 1, 1890, balance available		1,011.36

Abstract of proposals for work on the Eastern Branch Bridge, District of Columbia, opened April 4, 1890, by Lieut.-Col. Peter C. Hains, Corps of Engineers, U. S. Army.

CLASS A.

No.	Name and address of bidder.	Watchman's house.	Guard-fence. 335 square yards.		Painting under sides of through-spans.	Wooden sidewalk. 1,150 lineal feet.		Total.
			Price.	Amount.		Price.	Amount.	
4	William Rothwell, Washington, D. C.	$333.65	$1.96	$656.60	$549.00	$1.10	$1,265.00	$2,804.25

Abstract of proposals for work on Eastern Branch Bridge, District of Columbia—Cont'd.

CLASS B.

No.	Name and address of bidder.	Slope paving. 2,200 square yards.		Soiling. 1,000 cubic yards.		Curb. 1,150 lineal feet.	
		Price.	Amount.	Price.	Amount.	Price.	Amount.
1	Washington Granite Monument Company, Washington, D. C.	$1.75	$3,850.00	$1.90	$1,900.00	$1.85	$2,127.50
2	W. H. Mohler, Washington, D. C.....	2.00	4,400.00	.40	400.00	*1.48	1,702.00
3	M. F. Talty, Washington, D. C.....	1.10	2,420.00	1.50	1,500.00	1.80	2,070.00
4	William Rothwell, Washington, D. C	1.33	2,926.00	1.70	1,700.00	1.40	1,610.00
5	Norman Van Nostrand, Washington, D. C..	1.75	3,850.00	1.25	1,250.00	†1.75	2,012.50

* For granite; $1.85 for blue stone.
† For granite; $2.15 for blue stone.

No.	Name and address of bidder.	Gutters. 275 square yards.		Road-basins and drain-pipes.	Riprap. 2,300 cubic yards.		Total.
		Price.	Amount.		Price.	Amount.	
1	Washington Granite Monument Company, Washington, D. C.	$1.25	$343.75	$138.00	$4.25	$9,775.00	$18,134.25
2	W. H. Mohler, Washington, D. C.....	.45	123.75	75.00	.80	1,840.00	8,540.75
3	M. F. Talty, Washington, D. C	.50	137.50	160.00	1.60	3,680.00	9,967.50
4	William Rothwell, Washington, D. C...	.60	165.00	108.00	1.10	2,530.00	9,039.00
5	Norman Van Nostrand, Washington, D. C.	.40	110.00	75.00	1.15	2,645.00	9,942.50

Contracts entered into with William Rothwell, April 10, 1890, for Class A, and with W. H. Mohler, April 11, 1890, for Class B.

Abstract of contracts for construction of Eastern Branch Bridge, District of Columbia, in force during the fiscal year ending June 30, 1890.

No.	Name and address of contractor.	Date of contract.	Subject of contract.	Price.
*1	Groton Bridge and Manufacturing Company, Groton, N. Y.	Sept. 20, 1887	Construction of bridge.	$145,000.
*2	William Rothwell, Washington, D. C.	Apr. 10, 1890	Watchman's house....	$333.65.
			Guard-fence	$1.96 per square yard.
			Painting under side of through-spans.	$549.
			Wooden sidewalk	$1.10 per lineal foot.
*3	W. H. Mohler, Washington, D. C..	Apr. 11, 1890	Slope paving	$2 per square yard.
			Soiling	40 cents per cubic yard.
			Curb	$1.48 per lineal foot.
			Gutters	45 cents per square yard.
			Road-basins and drain-pipes.	$75.
			Riprap	80 cents per cubic yard.

* Completed.

K 3.

IMPROVEMENT OF SHENANDOAH RIVER, WEST VIRGINIA.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., February 7, 1890.

GENERAL: In response to the requirements of your letter of the 20th December, 1889, I have the honor to submit the following:

The first appropriation for improving the Shenandoah River, West

Virginia, was made by act approved June 14, 1880, which appropriated $15,000 for that purpose. The act of March 3, 1881, contains an appropriation of $2,500 more, and provides that neither appropriation shall be expended until any "corporate rights or franchises that may exist over said river shall have been relinquished to the United States, to the satisfaction of the Secretary of War."

The Shenandoah River Navigation Company, organized in 1872 under the laws of the State of West Virginia for improving the navigation, was at this time in existence, and had maintained for a short time a down-stream navigation for boats drawing not over 10 or 12 inches of water, on that portion of the river in West Virginia, but the works had been destroyed by a freshet in 1877, and subsequent thereto they were not repaired so as to be of any use.

On May 9, 1882, this company relinquished to the United States all its rights, interests, property, etc., and disbanded. The property thus relinquished to the United States consisted of certain dams, chutes, and locks, and the right of the company to collect tolls. It was found, however, that all the locks, dams, etc., had been built on the property of private individuals. No real estate was transferred. Of this fact we were apprised in January, 1885.

The charge of improving this river was transferred to me July 29, 1884, prior to which time it had been under charge of Col. William P. Craighill, Corps of Engineers.

In October of 1884 the United States sold at auction, under the provisions of the act of July 4, 1883, all the real estate and riparian rights it owned at Harper's Ferry, W. Va., and in January, 1885, the Solicitor of the Treasury, in a communication to the honorable the Secretary of War, questions the right of the United States to carry out the improvement contemplated. I inclose herewith a copy of the letter of the Solicitor of the Treasury, and of the act of July 4, 1884. That letter was referred to me for report, and on May 6, 1885, I submitted a report in which I recommended that Congress be asked to enact further legislation on this subject before the money be expended. On May 14, 1885, I was notified by the Department that the honorable the Secretary of War directed "that the further expenditure of the appropriation made for the improvement of the Shenandoah River be referred for the present to await further legislation." On April 17, 1866, I was directed to deposit the funds I held on account of this improvement with the Treasurer of the United States, to the credit of the appropriation.

Your letter of December 20, 1889, now directs me to submit "a project with estimate of cost for making navigation, for vessels drawing 18 inches at low water, on the Shenandoah River from the boundary line of Jefferson County, W. Va., and Clarke County, Va., to Shenandoah City, or to the pulp-mill of Savery at Millville."

Shenandoah City exists only on paper. It is not a city. On the map it is represented on the left bank of the Shenandoah River, a short distance above Harper's Ferry. The pulp-mill of Savery at Millville could not be found. There is no pulp-mill at Millville. Indeed there is no place in this vicinity that could be found called Millville, except Millville Station on the Valley Branch of the Baltimore and Ohio Railroad, about 4 miles from Harper's Ferry, and a place called Millville Mills, formerly called Snyder's Mills, about 1½ miles from Millville Station. There is no pulp-mill at either place. The pulp-mill of Savery is at Harper's Ferry. I understand Savery has two pulp-mills, one on the Potomac side of Harper's Ferry, and the other on the Shenandoah side. An improvement that leads to the place called Shenandoah City

is the same as to Savery's pulp-mill, for the latter is only a short distance below, on the slack-water that feeds the mill, and called Lake Quigley. The old Navigation Company had two locks near McDowell street, Harper's Ferry, by means of which boats could be locked down into the Shenandoah River and then across the Potomac to the Chesapeake and Ohio Canal. The destruction of the latter last June renders the locking down into the river unnecessary, for the present at least.

The following project is for an improvement from the boundary line of Jefferson County, W. Va., and Clarke County, Va., to Shenandoah City and the mill of Savery at Harper's Ferry. Beginning at the boundary line between Clarke County, Va., and Jefferson County, W. Va., to the head of what was formerly known as Little's Falls—a distance of 12½ miles—the river is made up of a series of pools separated by shoals and ledges, with but slight fall. The average slope of the river over this part is but little more than 2½ feet per mile. The pools have a depth of from 3 to 7 feet of water and are often a mile or more in length. Portions of the ledges project above the plane of low water, with intervening natural channels, in which the depth is from 4 to 9 inches. Through these ledges channels were opened by the Old Shenandoah Navigation Company from 10 to 12 feet wide and about 10 inches deep. Only one of these ledges now offers any special obstruction to navigation. This is the one at the former site of Smallwood's Mill, and near the old Shannondale Iron Works. This can be improved by excavating a channel and the construction of a sluice-wall. The estimated cost of the work from the Jefferson County line to Hopewell Mills, is as follows:

1,500 cubic yards of rock excavation at $4	$6,000
1,700 cubic yards of gravel excavation at $1	1,700
Sluice-wall	300
	8,000

The head of Little's Falls, 7 miles above Harper's Ferry, is now known as Hopewell Mills. There is no mill in operation, but the ruins of two mills still exist. At this place the route of the old navigation left the river, passing the crest of the falls by means of canal about 550 feet long, and a lock of 6 feet lift. The canal has been filled up by freshets and will have to be re-excavated. The old dam at the head of the fall has been washed away and should be rebuilt in part, so as to throw a sufficient amount of water into the canal.

Estimate for canal at Hopewell Mills.

3,300 cubic yards earth excavation, at 30 cents	$990
Riprap	200
Wing-dam, at head of falls, 300 cubic yards, at $3	900
	2,090

The lock at Hopewell Mills is in a very dilapidated condition. Some of the old masonry can be utilized, but much of it must be rebuilt. New gates are needed, and the lift-wall, the head and tail walls, and the wing-wall, must be practically rebuilt. The estimated cost is as follows:

Dressed-faced masonry, 70 cubic yards, at $18	$1,260
Rubble masonry, 350 cubic yards, at $6	2,100
Excavation, 200 cubic yards, at 50 cents	100
Upper gates	250
Lower gates	400
New miter-sills	40
Repairing and pointing up old masonry	250
Contingencies of estimate, 15 per cent	660
	5,060

No coffer-dam is needed as the canal above is filled up. Land will be required at Hopewell Mills (as shown on the accompanying map) for the site of the lock and the canal. A strip 50 feet wide would be ample. The people interested in the work state that such conveyances of land as may be needed will be made to the United States without charge.

After passing the lock at the Hopewell Mills, the route of the old navigation followed (down Little's Falls) the left bank through numerous sluices and a sort of a canal formed, in some places, by inclosing a part of the river-bed with dry masonry walls and in other places by excavating through the solid rock ledge. The canal is filled up with stone, gravel, and débris from freshets. The excavation through rock was but little over 10 feet wide, barely sufficient for the passage of the boats used in the old navigation, which were 9½ feet wide and drew 10 inches. The banks of the river are rocky and precipitous and the water is rough. At a distance of 1 mile below the lock at Hopewell Mills the dam supplying the Millville Mill (formerly known as Snyder's Mill) is reached. The fall in this mile is about 12 feet. Almost the entire length of this section of the river needs heavy work to restore navigation and make a channel 20 feet wide and 18 inches deep at low water. Much of the excavation, however, can be done at cheaper rates than at other points, owing to its proximity to the shore. The estimated cost of this section is as follows:

Rock excavation, 1,690 cubic yards, at $4	$6,760
Rock excavation, 1,250 cubic yards, at $2.50	3,125
Loose rock and gravel excavation, 4,760 cubic yards, at 60 cents	2,856
Sluice-wall and wing-dams, 2,321 cubic yards, at $2	4,642
Total	17,383

Say, $17,500.

From the Millville Dam the route of the old navigation was along the mill race, now supplying the flouring mill of the Millville Milling Company, at the foot of Little's Falls. A few hundred feet above the mill boats entered a lock and were passed into the river below the falls. The mill-race is about 1,800 feet long, from 20 to 25 feet wide, and from 3 to 5 feet deep. The estimated cost of work here is as follows:

Repair and rebuild 300 feet crib-dam, at $5	$1,500
Repair bank of race	100
	1,600

The lock is 12 feet wide and 95 feet long between quoin posts; lift, 13 feet. The lock is built largely of rubble masonry. The chamber walls should be repaired and raised, the head and tail walls rebuilt and repaired, the old masonry pointed up, and new gates put in. The lock is connected with the river below by a sluice-way. This should be re-excavated, and a short dam built with the excavated material to close a chute near the mill. In order to repair the lock it will be necessary to throw a coffer-dam across the bay in the mill-race above the head of the lock. The estimated cost of the work is as follows:

Coffer-dam, 50 linear feet, at $4	$200
60 cubic yards dressed face masonry, at $18	1,080
60 cubic yards rubble masonry, at $6	360
Upper gates	250
Lower gates	400
Excavation, 300 cubic yards, at 50 cents	150
Miter sills	40
Pointing up old masonry	100
Contingencies of estimate, 15 per cent	387
Total	2,967

Say, $3,000.

Estimate for sluice-way, below lock, to river.

190 cubic yards rock excavation, at $4	$760
575 cubic yards loose rock, etc., excavation, at $1	575
Contingencies of estimate, 15 per cent	200
Total	1,535

Say, $1,500.

Land will be required for the site of the lock and sluice, as shown on the map. A right of way at least will be required over the mill-race, over which boats must pass and which will supply the lock with water. The supply of water is ample for both the mill and the lock.

From the foot of Little's Falls to the head of Bull's Falls, a distance of 3 miles, there is a sufficient depth and the navigation is good except at one or two points where gravel bars have formed from the action of freshets. Leaving the foot of Little's Falls, the channel for navigation follows the left bank of the river until "Cat-tail Run" is passed, when it gradually crosses to the right bank. Following near the right bank to a point near Millville Station it again crosses to the left bank, which is then followed to and through Bull's Falls. Millville Station, on the Valley Branch of the Baltimore and Ohio Railroad, is 1½ miles below the foot of Little's Falls, 1½ miles above the head of Bull's Falls, and about 4 miles above Harper's Ferry. The estimated cost of removing gravel bars in this section is as follows:

1,500 cubic yards gravel excavation, at 75 cents	$1,125

At the head of Bull's Falls there are three old sluices, the walls of which should be repaired or rebuilt where necessary, the sluices re-excavated, and a new dam about 600 feet long built at the upper end of the upper sluice to deflect water into this and the sluices below.

Near the middle of Bull's Falls, at what is known as the "main pitch" of the fall, a wide ledge extends nearly across the river. Through this ledge, next to the left bank, there is a sluice of the old navigation system, 112 feet long and from 25 to 30 feet wide. The depth in the sluice is sufficient, but the current is too rapid. The wall at the upper end should be repaired and extended, and some excavation made at the same end to reduce the slope.

At the foot of Bull's Falls a channel about 200 feet long should be opened and a passage-way for boats made through an old dam. The estimated cost of the work at Bull's Falls is as follows:

470 cubic yards rock excavation, at $4	$1,880
700 cubic yards sluice walls and dams, at $3	2,100
380 cubic yards loose rock, stone, and gravel excavation, at $1.25	475
Removal of old dam, 20 cubic yards, at $2	40
Contingencies of estimate, 20 per cent	900
Total	5,395

Say, $5,400.

From the foot of Bull's Falls the route of the old navigation company was through a canal along the left bank down to McDowell street, Harper's Ferry, where there were two locks by means of which the level of the Potomac River was reached. The conditions are now changed. A dam has been built across the river at the locality designated on the maps as "Shenandoah City," so as to increase the head of water for Savery's mill. This dam makes slackwater nearly to the foot of Bull's Falls, so that to obtain the best route for navigation now is to abandon the old canal, which has filled up with débris, etc., and pass out from

the foot of Bull's Falls into the slackwater of the river. Near the new dam it passes into Lake Quigley at the head of Big Island, with slackwater to Savery's mill at Harper's Ferry.

Summary of estimate.

From Jefferson County line to head Little's Falls	$8,000
Canal at Hopewell Mills, head Little's Falls	2,000
Rebuilding lock at Hopewell Mills	5,060
Hopewell Mills to Millville Dam	17,500
Repairs to Millville Dam and mill-race	1,600
Repairs to lock at Millville Mill	3,000
Sluice at Millville Mill	1,500
Foot of Little's Falls to head Bull's Falls	1,125
Bull's Falls	5,400
Superintendence and contingencies, 10 per cent	4,527
Total	49,802

There is no trade on the river, except that occasionally a little wheat is boated down to Hopewell Mills and from there hauled to Millville Mills. The trade expected by the people should the improvement be made is in brick, lime, flour, wheat, iron ore, and lumber. The boats proposed to be used are called "gondolas." They are flat boats 76 feet long, 9½ feet wide, drawing about 10 inches. They were formerly built of new lumber on the upper reaches of the river, loaded, and then taken down to Harper's Ferry, where they were sold to be broken up for the lumber. They could not get back.

Harper's Ferry is a town of about 2,500 inhabitants. It possesses an excellent water-power, both from the Potomac and Shenandoah rivers, but there is no outlet by water from the place now. The Potomac is not navigable and the destruction of the Chesapeake and Ohio Canal has cut off the only water communication it ever had. All produce that now comes to Harper's Ferry must be consumed there or go from thence by rail.

From the foregoing estimate it will be seen that it will cost nearly $50,000 to put a small section of the river in a condition to enable boats drawing 18 inches of water to reach Harper's Ferry, and they will have to come from no distant point, unless the river be improved for a considerable distance higher up. When they get there they can not get back and must be broken up for the lumber of which they are built.

The old navigation system was destroyed by the freshet of 1877, a short time in fact after it had been built. It never was repaired or rebuilt. A similar freshet would probably destroy the greater part of the work herein proposed. These freshets occur about once in seven years, so that the expense of repair will be uncertain in amount though certain to be heavy.

It does not appear to me that it is a desirable work for the Government to undertake.

It is believed that the best way of doing the work is by hired labor and the purchase of materials in open market. It can only be carried on during the summer, when the water is warm enough for men to work in it, and when the river is low.

An annual appropriation for maintaining the work and keeping it in repair would be needed, estimated as follows:

One superintendent of repairs	$1,000
Labor and materials (annually)	2,500
	3,500

As the number of boats to go through would not be great, it is probable that one man could attend to both locks, though they will be over 1 mile apart.

I transmit herewith a tracing* of the river from the boundary of the State of West Virginia to Harper's Ferry, and on a larger scale one* of that portion included between Hopewell Mills and Millville Mills.

Very respectfully, your obedient servant,

PETER C. HAINS,
Lieut. Col., Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

AN ACT authorizing and directing the sale of the real estate and riparian rights now owned by the United States at Harper's Ferry, in the State of West Virginia.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Solicitor of the Treasury is hereby authorized and directed to make sale of all the real estate and riparian rights now owned by the Government of the United States at Harper's Ferry, in the State of West Virginia, such sale to be at public auction, without reservation, except as hereinafter provided, to the highest bidder, and after not less than four weeks public advertisement of the same in such newspapers as the Solicitor, with the consent of the Secretary of the Treasury, may select for such publication: *Provided*, That the property shall not be sold for a less sum than twenty thousand dollars.

SEC. 2. That said real estate and riparian rights shall be sold either as an entirety or in such parcels and divisions as in the judgment of the said Solicitor shall be most promotive of the interests of the United States, and upon such terms as to cash payment and credits as the Secretary of the Treasury may prescribe, but so that at least one-third of the purchase money shall be paid in cash, and the credit portion shall bear interest at the rate of six per centum per annum.

SEC. 3. That upon the compliance of any purchaser or purchasers of the whole of any parcel purchased as aforesaid with the terms of sale, such purchaser or puchasers shall be let into possession of the premises so purchased; and upon full payment of the purchase money and interest (if any be due), the Solicitor of the Treasury, for and in behalf of the United States, shall make, seal, and deliver to the purchaser or purchasers good and sufficient deed or deeds, conveying all the right, title, interest, and estate of the United States in said property or parcel thereof, as the case may be, in fee-simple.

SEC. 4. That this act shall be in force from its passage.

Approved July 4, 1884.

LETTER OF THE SOLICITOR OF THE TREASURY.

DEPARTMENT OF JUSTICE,
OFFICE OF THE SOLICITOR OF THE TREASURY,
Washington, D. C., January 15, 1885.

SIR: I have the honor to submit for your information and for such action as you may be pleased to take, the following statement touching the water-power property of the Shenandoah River at Harper's Ferry, W. Va., formerly the site of the United States rifle works at that place.

On the 22d of October last, after advertising the same for a period of four weeks in the vicinity of the property, as well as in several of the large commercial and manufacturing centers of the country, and in accordance with the direction of an act of Congress approved July 4, 1884, I offered the said property together with the water-power of the Potomac River at the same place by public auction and caused the two tracts to be struck off for a considerable sum of money to Thomas H. Savery, who was the highest bidder. The said Savery complied with the terms of purchase prescribed by the said act of Congress, viz, the payment into the Treasury of one-third of the purchase money and by the execution of his two promissory notes payable in one and two years for the remainder.

---

* Tracings omitted; printed in Senate Ex. Doc. No. 65, Fifty-first Congress, first session.

According to the provision of that act he was formally let into possession of the premises which he now holds; and he is entitled to a conveyance by deed upon the full payment of the purchase money. The principal value of this property, indeed almost the entire value of the same, as I understand, consists in the water-power privileges and riparian rights of the two rivers held by the United States for a long period previously, and which have vested and were intended to vest by the sale to which I have referred. But by an act of March 3, 1881, vol. 21, page 471, making appropriations for certain rivers and harbors, the sum of $2,500 is appropriated for the improvement of the Shenandoah River aforesaid, with the proviso, however, that this sum and the amount of a previous appropriation shall not be "expended until any corporate rights or franchises that may exist over said river shall have been relinquished to the United States to the satisfaction of the Secretary of War."

By the terms of the sale made by me as well as by law the purchaser is entitled to the entire water-power of the Shenandoah River as held by the United States. According to my view of the matter there existed no rights or franchises in the water privileges of this river jointly with or antagonistic to the United States, and that such purchaser acquired all incidents to those privileges, among which it may be claimed is the right to erect and to maintain dams, to open or widen waste-weirs, and in fact to adopt all means necessary to supply a required volume of water. It accordingly becomes a question for serious consideration whether the riparian rights so acquired by him, and guarantied by act of Congress, passed subsequently to the acts authorizing the improvement of that river, are not likely to be infringed, materially impaired, or perhaps destroyed in the progress of the work contemplated by the appropriation, and it may be likewise a subject of consideration, as I respectfully submit, whether, in view of the property rights which have so vested since the appropriations were made, the said work should go on, and in fact whether it is now a practicable measure for the Government to accomplish.

I have the honor to be, very respectfully,

HENRY S. NEAL,
Solicitor of the Treasury.

Hon. ROBT. LINCOLN,
Secretary of War.

APPENDIX L.

IMPROVEMENT OF PATUXENT RIVER, AND OF THE HARBORS AT BRETON BAY AND ST. JEROME'S CREEKS, MARYLAND—OF THE CHANNEL AT MOUNT VERNON—OF RAPPAHANNOCK RIVER AND YORK RIVER, VIRGINIA—OF TRIBUTARIES OF THE LOWER POTOMAC, AND OF CERTAIN RIVERS IN VIRGINIA AND NORTH CAROLINA.

REPORT OF MR. S. T. ABERT, UNITED STATES AGENT IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1890, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

IMPROVEMENTS.

1. Patuxent River, Maryland.
2. Channel at Mount Vernon, Virginia.
3. Breton Bay, Leonardtown, Md.
4. Nomini Creek, Virginia.
5. Harbor at entrance of St. Jerome's Creek, Maryland.
6. Rappahannock River, Virginia (including Urbana Creek).
7. Totusky River, Virginia.
8. Mattaponi River, Virginia.
9. Pamunky River, Virginia.
10. York River, Virginia.
11. Chickahominy River, Virginia.
12. Staunton River, Virginia (from Pig River to Randolph).
13. Dan River between Madison, N. C. and Danville, Va.
14. Removing sunken vessels or craft obstructing or endangering navigation.

EXAMINATIONS AND SURVEYS.

15. Chickahominy Creek (River), Virginia.
16. Occoquan Creek, Virginia.
17. Aquia Creek, Virginia.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., July 1, 1890.

GENERAL: I have the honor to submit herewith my annual report for the works of improvement of rivers and harbors which have been under my charge during the fiscal year ending June 30, 1890.

* * * * * * *

Very respectfully, your obedient servant,

S. T. ABERT,
United States Agent.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

L 1.

IMPROVEMENT OF PATUXENT RIVER, MARYLAND.

HISTORY OF OPERATIONS.

For "description of original condition" and "plan of improvement" see Report of Chief of Engineers for 1888, Part II, pages 846 to 851.

WORK DONE DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

The work was re-advertised, and bids were opened August 28, 1889. The contract was assigned to Thomas P. Morgan, the only bidder, at 20 cents per yard.

The material was deposited in Broad, Mundy's, and Mack's creeks, and the Upper Thoroughfare, distant from one-half to 2½ miles.

AMOUNT EXPENDED AND RESULTS OBTAINED TO JUNE 30, 1890.

The appropriation of August 11, 1888 ($5,000), was expended in dredging 18,295 cubic yards from Bristol Bar. The channel is now about 120 feet wide and 12 feet deep. The extreme length is 794 feet.

FUTURE OPERATIONS.

To make the channel at Bristol Bar about 200 feet wide and 12 feet deep, according to the project, 72,505 cubic yards should be dredged from it.

The estimate for improvement of Bristol and Swann's Point bars was $80,000.

Warren's Reach and Pope's Shoal have not been surveyed, the appropriation having been exhausted in dredging at Bristol Bar.

The following appropriations have been made:

August 11, 1888	$5,000.00

A chart of Bristol Bar accompanies this report.

Money statement.

July 1, 1889, amount available		$4,744.71
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	4,743.21	
July 1, 1890, outstanding liabilities	1.50	
		4,744.71
Amount appropriated by act of September 19, 1890		6,000.00
Amount (estimated) required for completion of existing project		69,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		23,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

STATISTICS OF TRADE.

Mr. Henry Williams, agent of the Weems Line of steamers, writes as follows:

I have, in compliance with your request, calculated the tonnage of Patuxent River for 1889, and find it to be about 33,720 tons. This includes the estimated business done by all of the sail-boats trading from that river, whose tonnage I had to approximate. I think the estimate about correct.

TONNAGE FOR 1889.

As stated above, the tonnage for calendar year 1889 was about 33,720 tons. The first appropriation was August 11, 1888, $5,000.

NOTE.

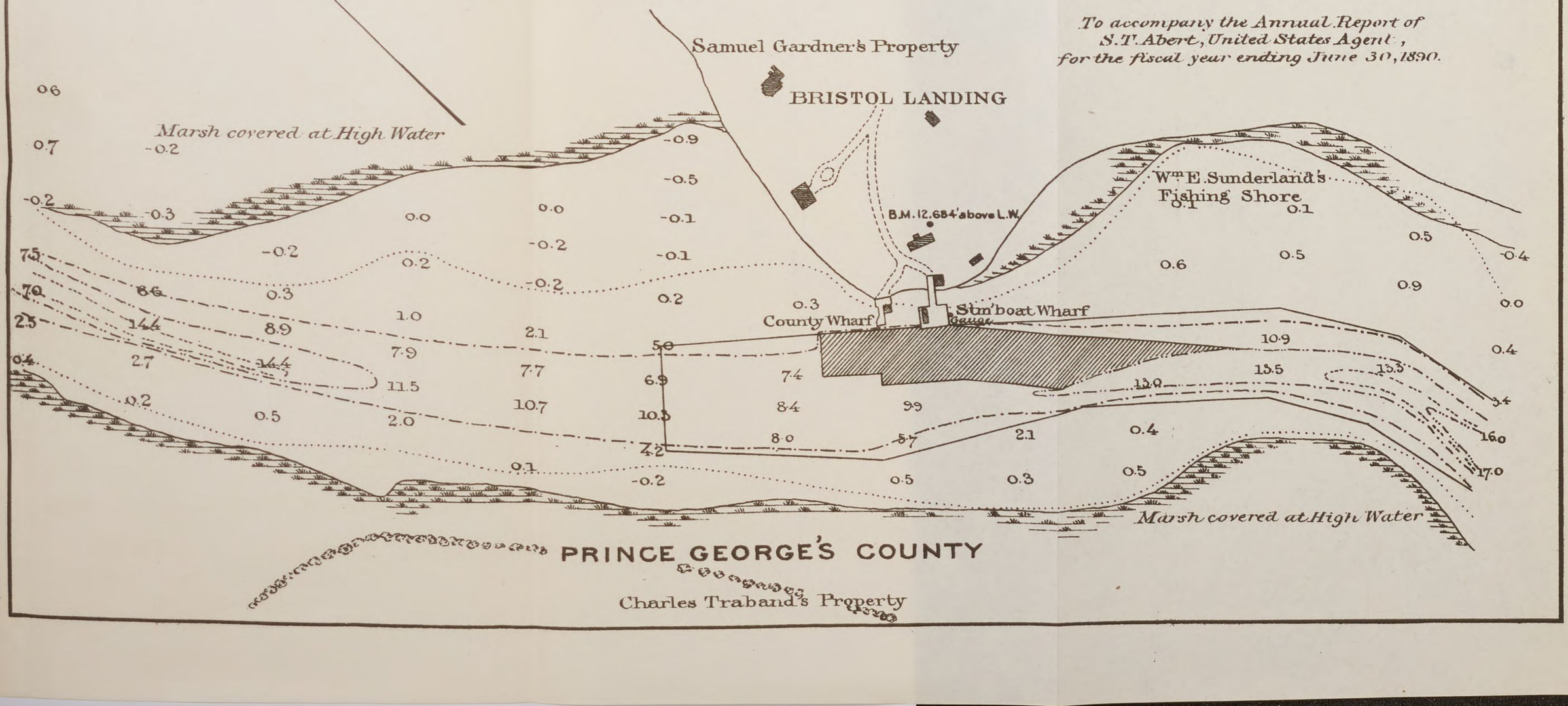
The soundings are expressed in feet and refer to Mean Low Water.
Mean Range of Tide is 2.3 ft.
Curves are represented thus: 6 ft. – · – · –, 12 ft. – ~ – ~ –, 15 ft. – – – –, 18 ft. – – – –
Dredging done from September 18, 1889 to January 2, 1890 to a depth of 12 feet at low water is shown thus: ▨
Dredging proposed in project indicated by solid line thus: ——

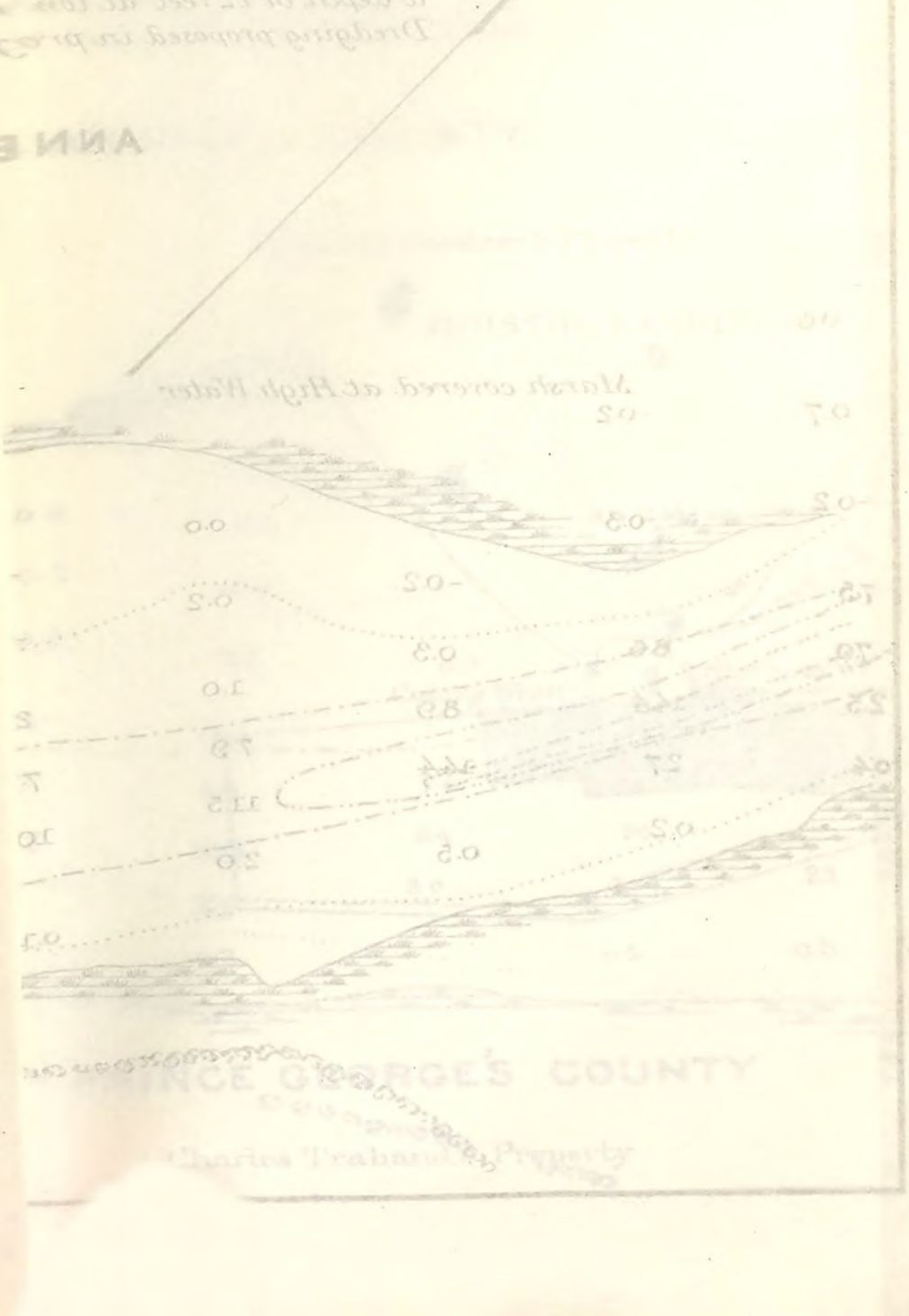
BRISTOL BAR
PATUXENT RIVER
MARYLAND

Scale of feet.

100 50 0 100 200 300 400 500 ft.

To accompany the Annual Report of S. T. Abert, United States Agent, for the fiscal year ending June 30, 1890.





CHESAPEAKE BAY

To accompany the Annual Report of
S. T. Abert, United States Agent,
for the fiscal year ending June 30, 1890.

INDEX MAP

POTOMAC RIVER

from

Washington to Chesapeake Bay.

1890

Scale of miles

1 ½ 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

(approximate)

The figures in brackets signify miles from Washington.

✳ Signifies Light House.

NOTE.

Least channel depth from Washington to Chesapeake Bay.

(Depths given at mean low water.)	Distance below Washington.	
From Arsenal Pt. (Wash.) to Mattawoman Shoal	28 miles	27 ft.
Mattawoman Shoal		19 "
From Mattawoman Shoals to Lower Cedar Pt.	61½ "	21 "
" Lower Cedar Pt. " Colonial Beach	67 "	27 " } Kettle Bottom Shoals.
" Colonial Beach " Wicomico River	74 "	19 " }
" Wicomico River " Blakistone Id	80 "	25 "
" Blakistone Island " Chesapeake B.	106 "	30 "

VIRGINIA

WASHINGTON

Eastern Branch

Giesboro Pt.

U S Naval Magazine

Four Mile Run

Marbury Pt.

Oxon Cr.

(5) ALEXANDRIA

Jones

Hunting Cr.

Rosier's Bluff (Ft. Foote) (8)

A. & F. R. R.

Broad Cr.

Riverview

Fort Washington (11)

Piscataway Cr.

Sheridan Pt.

Mockley Pt.

(14) Mount Vernon

Dogue Cr.

Marshall Hall (15)

Accotink Cr.

Pohick Cr.

Occoquan Cr.

Gunston Cove

Hallowing Pt.

Occoquan

Woodbridge

Craney I. (21)

Glymont (22)

High Pt. (26)

Indian Head

Neabsco Cr.

(27) Freestone Pt.

Powell's Cr.

Deep Pt.

Mattawoman Cr.

Mattawoman Shoal

(29) Cockpit Pt.

Stump Neck

Dumfries

Chicomuxen Cr.

Quantico Cr.

Budd's Ferry

(33) Potomac City

Liverpool Pt. (36)

Maryland Pt. (45)

Brent's Pt. (41)

Aquia Cr.

Marlborough Pt.

Potomac Cr.

Rappahannock R. & Potomac R.

Windmill Pt.

Chapel Pt.

Popes Cr.

Landing

Nanjemoy Cr.

Cedar Pt. (53)

Dahlgren Shoal

Matthias Pt.

(55)

(59)

Persimmon Pt.

Lower Cedar Pt. (62)

Swan Pt.

Cod Pt.

Kettle Bottom Shoals

Matomkin Pt.

Upper Machodoc Cr.

Bluff Pt. (68)

Colonial Beach

Mattox Cr.

Ruins

Pope's Cr.

Washington's Birthplace (Wakefield.)

Nomini Cliffs

Nomini Bay

Nomini Cr.

Wicomico River

Leonardtown

Magnetic Meridian

St. Clements Bay

Breton's Bay

Higgin's Pt.

Blakistone I. (80)

St. Catharines I.

Ragged Pt. (85)

Lower Machodoc R.

Piney Pt. (92)

St. George's I.

St. Mary's R.

Kitt's Pt. (99)

Cornfield Pt.

Cornfield Harbor

Pt. Lookout (106)

St. Jeromes

Pt. No Point

Patuxent River

Drum Pt.

Cedar Pt.

CHESAPEAKE BAY

Lynch's Pt.

Yeocomico R.

Coan R.

Hull's Cr.

✳ (110)

Smith's Pt.

MARYLAND

L 2.

IMPROVEMENT OF POTOMAC RIVER AT MOUNT VERNON, VIRGINIA.

HISTORY OF OPERATIONS.

For "Reference to reports," "Description of original condition," and "Plan of improvement," see Report of Chief of Engineers for 1888, Part II, pages 813 and 814.

WORK DONE DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

No work was done during the year for want of funds.

AMOUNT EXPENDED AND RESULTS OBTAINED TO JUNE 30, 1890.

From the beginning of the improvement to June 30, 1890, $14,500 have been expended. The channel has a width varying from 60 to 100 feet, and the basin a width of 360 feet. The depths in the channel and basin within the limits mentioned vary from 9 to 12.8 feet.

FUTURE OPERATIONS.

A chart showing the condition of the channel and the dimensions desired by the Mount Vernon Association will be found in the Report of the Chief of Engineers for 1889. This chart exhibits a channel which will have a depth of from 9 to 10 feet at low water and a width of not less than 200 feet. Sixty-eight thousand cubic yards of excavation will be required to complete this chonnel. The cost will be about $11,500.

The following appropriations have been made:

March 3, 1879	$4,000
June 4, 1880	3,000
March 3, 1881	1,500
Augnst 11, 1888	6,000
Total	14,500

The following drawing accompanies this report:

General index map of Potomac River.

Money statement.

July 1, 1889, amount available	$528.56
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	528.56
Amount appropriated by act of September 19, 1890	2,500.00

STATISTICS OF TRADE.

No reply was received in response to request for statement to December 31, 1889.

Mr. Harrison H. Dodge, Mount Vernon, Va., writes as follows, under date of March 14, 1890:

"In answer to your communication of the 12th instant I will state that the total number of (boat) visitors to Mount Vernon during the calendar year ending December 31, 1889, was 38,586

"The new steam-boat will be called the *Charles Macalester*, and is expected to start on route about May 10, 1890. Her dimensions are: Length, 203 feet; beam 30 feet; tonnage, 742.75. We expect the boat to make two regular trips to Mount Vernon daily, and look forward to considerable increase of trade.

"The need of further improvement to channel and basin will best be determined when the new boat has tested present conditions."

L 3.

IMPROVEMENT OF BRETON BAY, LEONARDTOWN, MARYLAND.

HISTORY OF OPERATIONS.

For "Reference to reports," "Description of original condition," and "Plan of improvement," see Report of Chief of Engineers for 1888, Part II, Pages 815 and 816.

WORK DONE DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

No work was done during the fiscal year for want of funds. Under the appropriation of August 11, 1888, the work was completed March 2, 1889.

AMOUNT EXPENDED AND RESULTS OBTAINED TO JUNE 30, 1890.

From the beginning of the improvement, $32,500 have been expended in excavating 185,429 cubic yards of material at rates varying from 10 to 18 cents per cubic yard.

At the close of the work in March 1888, the basin at the upper end of the channel was 645 feet long by 370 feet wide, narrowing to a width of 150 feet in 335 feet. From the lower end of the basin, the channel continued 150 feet wide for a distance of 1,870 feet, and for a farther distance of 1,380 feet around the turn at Buzzard Point the width varied from 185 to 280 feet. The depths varied from 8.5 to 14.6 feet.

FUTURE OPERATIONS.

The basin and channel should be widened to the dimensions recommended in the amended project, and the channel continued for a distance of about 1,960 feet, until the depth of 9 feet at low water is reached.

The following appropriations have been made:

June 18, 1878	$5,000
March 3, 1879	4,000
June 14, 1880	3,000
March 3, 1881	3,000
August 2, 1882	5,000
July 5, 1884	3,000
August 5, 1886	6,500
August 11, 1888	3,000
Total	32,500

The work is in the collection district of Annapolis, the port of entry, and in the fifth light-house district, near Blakiston Island Light.

Leonardtown is one of the landings of the Potomac River and Baltimore boats.

Money statement.

July 1, 1889, amount available	$839.98
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	839.98
Amount appropriated by act of September 19, 1890	5,000.00
Amount (estimated) required for completion of existing project	12,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	12,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

STATISTICS OF TRADE.

TONNAGE.

Mr. C. W. Ridley states that the total tonnage to and from Breton Bay during the calendar year 1889 was 6,172 tons, valued at $293,972.36. This is the total tonnage of steamers and sailing vessels, and is probably the most correct statement received up to the present time.

L 4.

IMPROVEMENT OF NOMINI CREEK, VIRGINIA.

HISTORY OF OPERATIONS.

For "Reference to reports" and "Description of original condition," see Report of Chief of Engineers for 1888, Part II, pages 816 and 817.

Plan of improvement.—The project for improvement, adopted in 1873, provided for a channel 100 feet wide and 9 feet deep at low water.

In 1879 an increase in width to 150 feet was recommended, which was again submitted in 1882 with an estimate.

In 1885 a further increase to 200 feet was deemed necessary to meet the increased demands of trade. This amendment included a tributary channel, which would increase the tidal supply of the harbor; and the sinking of mats, to obstruct the cross-currents, which interfered with navigation and tended to fill a part of the channel with sand.

The appropriations have been barely sufficient to keep the channel navigable, and its narrowness renders it difficult and dangerous at night and during the prevalence of winds from the northeast and northwest.

WORK DONE DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

Active operations were suspended for want of funds. Under the appropriation of $5,000, made August 11, 1888, the contract for dredging in the mouth of the channel was completed June 12, 1889.

AMOUNT EXPENDED AND RESULTS OBTAINED TO JUNE 30, 1890.

At the close of operations in 1883 the dredged channel was about 100 feet wide and 9 feet deep from the 9-foot curve, outside the entrance to the creek, to White Oak Point, a distance of 4,400 feet.

For six years previous to 1889 no dredging had been done in Nomini. During this period the cut was reduced in width and depth by deposits of sand at several places. The channel had also shoaled to a depth of 7.2 feet above the upper limits of the previous cut. In 1889, under the last contract, a channel 94 feet wide and about 1,470 feet long was re-dredged through the bar outside the entrance of the creek. The depths in this cut vary from 8.9 feet to 13.8 feet.

From the beginning of operations to June 30, 1890, $36,986.61 have been expended in dredging 91,586 cubic yards of sand, shells, and gravel, at rates varying from $15\frac{3}{4}$ to 30 cents per yard.

FUTURE OPERATIONS.

Work to be done to complete the project, as it stood at the date of last annual report, consists in widening the channel as near to 200 feet

as the funds permit from the 9-foot curve in Nomini Bay to Hickory Point, and in cutting an oblique tidal channel.

Lower Machodoc River, about 2 miles below, could be improved at less cost than Nomini, but is not so convenient as a place of shipment for the produce of the farms of Westmoreland County.

The following appropriations have been made:

May 3, 1873	$10,000
June 23, 1874	6,000
March 3, 1875	5,000
March 3, 1879	2,500
June 14, 1880	5,000
March 3, 1881	2,000
August 2, 1882	2,000
August 11, 1888	5,000
Total	37,500

The work is in the collection district of Tappahannock, which is the nearest port of entry. The nearest light-house is Blakistone Island Light, in the fifth light-house district.

Money statement.

July 1, 1889, amount available	$689.20
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	175.81
July 1, 1890, balance available	513.39
Amount appropriated by act of September 19, 1890	5,000.00
Amount available for fiscal year ending June 30, 1891	5,513.39
Amount (estimated) required for completion of existing project	30,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	30,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

STATISTICS OF TRADE.

Mr. F. E. Tubman reports the value of trade by water, carried by sail-vessels, $147,150. He says the number of vessels varies with the demand, and that several lumbermen have reported that many of their vessels have annulled their contracts after coming to the mouth of the creek and seeing the dangerous channel. Mr. Needham, of the steamer *Sue*, reports 337 tons carried during 1889. Mr. C. W. Ridley furnished a statement "showing freight tonnage and value of same to and from Nomini Creek during the calendar year 1889" amounting to 13,542 tons, valued at $645,005.46. This is total tonnage by steamers and sail-vessels.

TONNAGE.

Total for 1889, 13,542 tons.

L 5.

IMPROVEMENT OF HARBOR AT ENTRANCE OF ST. JEROME'S CREEK, MARYLAND.

HISTORY OF OPERATIONS.

For "Reference to reports," "Description of original condition," and "Plan of improvement" see Report of Chief of Engineers for 1888, Part II, page 818.

WORK DONE DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

No work has been done during the year for lack of funds.

The Fish Commission has abandoned the station at St. Jerome's Creek.

No examination has been made since the close of work done under the appropriation of July 5, 1884.

If the bar at the mouth were removed, St. Jerome's would afford a convenient harbor of refuge, particularly for small sailing vessels and oyster boats. At no other point south of the Patuxent can a harbor be found as favorably situated.

The following appropriations have been made:

March 3, 1881	$6,500
August 2, 1882	5,000
July 5, 1884	15,000
Total	26,000

The work is in the collection district of Annapolis. The nearest light-house is Point Lookout, 6 miles distant.

Money statement.

July 1, 1889, amount available	$864.89
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	864.89
Amount (estimated) required for completion of existing project	26,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

STATISTICS OF TRADE.

The value of trade in 1884, as reported by Mr. G. G. Joynes, was $167,800. In 1888 Mr. J. T. Powell reported value of trade $215,500.

Mr. Joseph V. Richardson, Ridge P. O., Md., reports value for 1889, $370,000. He reports 100 sail-vessels, greatest draught 5 feet. Vessels of this draught, he says, come in at high tide.

On account of work done by Government, competition, he says, has ensued, and the rates of freight are considerably lessened.

He reports 5 steam-mills, business in 1889, $40,000, and 12 business houses, ditto in 1889, $100,000; and adds:

"I have no hesitation in asserting that, if the desired appropriation be allowed, great improvements in commercial facilities will ensue, new industries will be originated and old [industries] will be greatly increased."

L 6.

IMPROVEMENT OF RAPPAHANNOCK RIVER, VIRGINIA.

HISTORY OF OPERATIONS.

For "Reference to reports," "Description of Original Condition," and "Plan of Improvement," see Report of Chief of Engineers for 1888, Part II, pages 819 and 820.

WORK DONE DURING FISCAL YEAR ENDING JUNE 30, 1890.

(*a*) *Work by contract.*—At the beginning of the fiscal year, work was in progress under contract with George E. Ward for constructing dikes

and mats at Fredericksburg and Spottswood bars. About 450 feet of dike at Fredericksburg bar had been partly completed.

The progress of the work was much delayed by freshets, and the time for completion of the contract was extended from September 3 to November 1, 1889. Work under this contract at Fredericksburg bar was completed in September, 1889, and consisted of 156.5 feet of retaining-dike (Class I) at $4.53 per foot, and 307.7 feet of shore connection (Class III) at $2.65 per foot.

Work was then begun at Spottswood bar. On October 7, 1889, work was stopped by B. D. Greene, one of the sureties on Ward's contract, on account of the disappearance of the contractor, Ward.

On October 29, 1889, Mr. Ward's contract was declared annulled by reason of his failure to prosecute the work.

Dikes of Class II and Class III were under construction at Spottswood Bar, but when work was suspended no dike had been completed.

The construction of dikes and mats at Spottswood Bar was resumed on November 16, 1889, under contract with B. D. Greene at the prices named in the contract with Ward, and the work was completed on January 14, 1890. The dikes built at Spottswood Bar, under appropriation of August 11, 1888, were 154.8 linear feet of shore connection (Class III) at $2.65 per foot, and 1,290.9 feet of brush mattress dikes (Class II) at $3.45 per foot.

Of these dikes 713 8 feet of Class II and 154.8 feet of Class III were partly constructed by Ward and completed by Greene.

(*b*) *Work by hired labor.*—The steam-hoister was repaired in October, 1889, at a cost of about $90; in November, 1889, a break, 36 feet long, in Dike No. 4 at Fredericksburg, was repaired at a cost of $56; twelve snags and one overhanging tree were removed from the channel near Hop Yard Wharf, 19 miles below Fredericksburg, in December, 1889, at a cost of about $61. The steam-hoister was temporarily employed on Mattaponi and Pamunky rivers from the beginning of the fiscal year until September 28, 1889, and was employed at Urbana Creek during parts of November and December, 1889, after which it was placed in charge of a watchman at $30 per month.

An examination of the condition of the bars from Fredericksburg to Farley Vale was made in January, 1890, at the close of work under the last appropriation.

AMOUNT EXPENDED AND RESULTS OBTAINED TO JUNE 30, 1890.

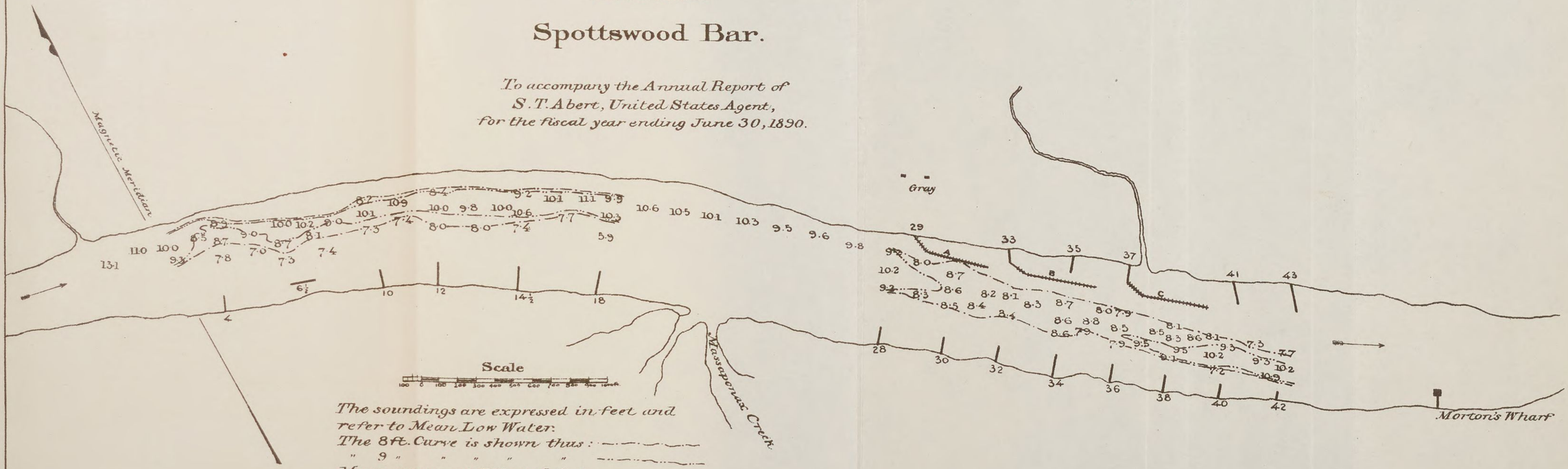
From the adoption of the project in 1879, to the close of the fiscal year 1890, $108,421.30 were expended between Fredericksburg and Port Royal, a distance of 29½ miles, in dredging 165,875 cubic yards of sand, in the construction and repair of dikes, and in removing dangerous rocks, snags, and fallen and overhanging trees. Except the removal of a small number of snags at Hop Yard, this work was confined to the distance of 12.6 miles between Fredericksburg and Farley Vale. The dikes constructed are designed merely to maintain the depth after dredging shall be done, and not to create the depth required in the channels. Notwithstanding the injurious action of many heavy freshets in the summer of 1889, the dikes, though incomplete in length, have maintained the channels through the bars at about their previous depth. In January, 1890, the least depth at the bars for 12.6 miles below Fredericksburg, except at Fredericksburg and Spottswood bars, was rather more than 9 feet. The channels at these two bars had minimum depths of about 8 feet at low water and widths generally

RAPPAHANNOCK RIVER

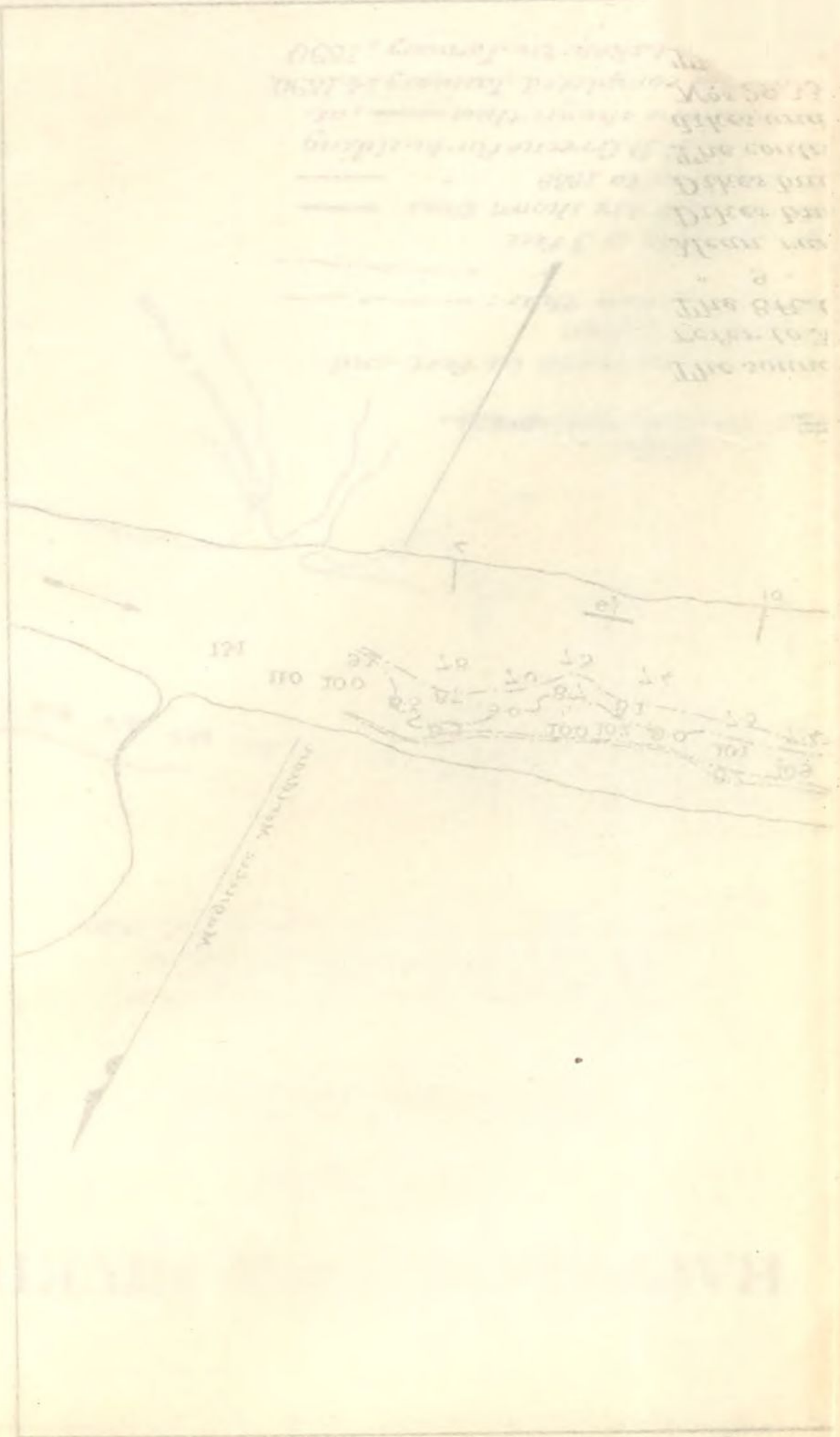
VIRGINIA

Spottswood Bar.

To accompany the Annual Report of
S. T. Abert, United States Agent,
for the fiscal year ending June 30, 1890.



The soundings are expressed in feet and refer to Mean Low Water.
The 8 ft. Curve is shown thus: —·—·—·—
" 9 " " " " —··—··—··—
Mean range of Tide is 3 feet.
Dikes built in 1889 are shown thus: ▬▬▬
Dikes built previous to 1889 " ——
The contract with B. D. Greene for building dikes and extensions shown thus ▬▬, at Nos 29, 33 & 37, was completed January 14, 1890.
The soundings were taken in January, 1890



more than 100 feet. The navigable depth at high water varied from 11 to 15 feet for 12.6 miles, the distance undergoing improvement.

The following table gives the results of the improvement at each of the bars:

Locality.	Depth at low water before improvement.	Least channel depth at low water January, 1890,
	Feet.	*Feet.*
Fredericksburg Bar, below steam-boat wharf	*4.0	†8.0
Pollock's Bar	7.3	9.0
Bernard's Bar	8.5	9.0
Pratt's Bar	8.3	9.0
Spottswood Bar, upper	6.0	8.5
Spottswood Bar, lower	6.0	8.0
Castle's Ferry Bar	8.0	9.5
Farley Vale Bar	8.0	9.5

*About.

†A small bar exists at and immediately below the steam-boat wharf, at which the least depth is about 6.5 feet; but it is comparatively unimportant, since it is just at the head of navigation.

Stated in general terms, about two-thirds of the work to be accomplished under the project between Fredericksburgh and Farley Vale, a distance of 12.6 miles, has been done.

Nothing has been done towards the improvement of the bars at Nanzatico Reach, 33 miles below Fredericksburgh, and near Tappahannock, 61 miles below Fredericksburgh. It is considered more important to first complete the improvement above.

The estimate, made in 1879, for the improvement of the last-named bars amounts to $205,700.

WORK DONE NOT PROVIDED FOR IN THE ESTIMATE OF 1879.

The project of 1879 provided only for the actual cost of excavating a channel, and for regulating works to keep it open. No provision was made in the estimate for the maintenance of the channel during eleven years which have elapsed since the adoption of the amended project, nor for the repair of damage done to the improvement by the action of the elements. These effects are due to causes, the operation of which can be neither suspended nor abridged. Much work in addition to that provided for in the estimate has been necessary in order to keep the river open to navigation during the long continuance of the improvement. This work has been as follows: Removing snags brought down by annual freshets; protecting banks from erosion caused by freshets, and by waves produced by the large steam-boats; mattressing the bottom to protect the dikes, and to confine the action of the current to the channel; repairing dikes, made necessary by the natural decay of timber after an exposure of ten or more years, and by the action of ice and heavy freshets to which the structures are subjected; removing dangerous rocks whose existence was discovered during the progress of work; redredging the channels, which was necessary to maintain navigation; and making additions to the systems of dikes and wing-dams provided for in the estimate. An increased amount has also been required for contingent expenses on account of the length of time since work began. The bars which have shifted from their original position, by reason of the contraction of the width of the river, have, as was

anticipated, re-formed farther down, thus requiring some work at new points. The same results may be looked for at lower parts of the river.

The extra expenditures for repairs enumerated above with the additional contingent expenses, due to delays and suspensions, will increase the total cost, but are not properly chargeable to the original estimate which did not contemplate the prolonged duration of the work. The original estimate was $291,000. The question of the formation of new bars is too indefinite to be provided for by any estimate which can be made. An annual expenditure will be required upon the river between Fredericksburgh and Farley Vale, for removing snags, for repair to dikes, and protection of the banks, and for a small amount of dredging of sand deposited by freshets. The yearly expenditure for this purpose will vary with the action of ice and freshets, but it can be estimated at from $5,000 to $7,500.

FUTURE OPERATIONS.

As Fredericksburg is the most important city on the river, and as the channel to it is difficult to maintain, the improvement immediately below should be placed in a condition as complete as practicable before beginning work elsewhere.

At the close of 1881 a pile-driver and snag-boat was purchased at a cost of $600 for use on the Rappahannock. It has been twice repaired, making the cost amount to about $1,900.

It was fitted with propelling power, and has been used at Totusky, Urbana, and on the Mattaponi and Pamunky rivers, to which it has twice made a safe voyage by way of the bay.

It has paid for itself thrice over, but is worn out and should be replaced by a new and better plant to be used for the same purpose. I would recommend the construction of a suitable snag-boat to be used on the Rappahannock, and, when needed, upon the other rivers named above.

The amount expended on former projects was $90,500. The following appropriations have been made for the present project:

June 14, 1880	$25,000
March 3, 1881	15,000
August 2, 1882	17,000
July 5, 1884	20,000
August 5, 1886	20,000
August 11, 1888 ($15,000, of which $3,000 was for Urbana)	12,000
Total	109,000

These appropriations were made under the estimate of 1879 for improving the river from Fredericksburgh to the 15-foot curve near Tappahannock, a distance of 64½ miles.

Estimate of 1879	$291,000
Amount appropriated to date	109,000
Balance due on estimate	182,000

The work is in the collection district of Tappahannock, which is the nearest port of entry. The nearest light-house is Bowler's Rock light-house in the fifth light-house district.

A map of Spottswood Bar, showing work done during the fiscal year and the condition of the bar in January, 1890, accompanies this report.

Money statement.

July 1, 1889, amount available		$2,413.94
July 1, 1889, amount covered by existing contracts		7,000.00
		9,413.94
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$6,886.17	
July 1, 1890, outstanding liabilities	1,949.07	
		8,835.24
July 1, 1890, balance available		578.70
Amount appropriated by act of September 19, 1890		15,000.00
Amount available for fiscal year ending June 30, 1891		15,578.70
Amount (estimated) required for completion of existing project		167,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		90,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

STATISTICS OF TRADE.

The river affords to the vicinity of Fredericksburg a route for the receipt and shipment of freight, competing with the Atlantic Coast Line system of railroads, and to a well-populated agricultural district extending along both sides of the river for its whole navigable length of 106½ miles, and including eight counties of Virginia, it provides the only means of transporting freight to and from the cities of New York, Philadelphia, Baltimore, and Norfolk. No complete statement of trade for 1889 could be procured. In 1888 five tugs and eighteen barges carried from Fredericksburgh to Philadelphia 48,600 tons of freight, consisting mainly of railroad-ties and wood valued at $150,000.

Three schooners were regularly engaged in the grain and coal trade between Fredericksburgh and points on the river and on Chesapeake Bay.

The greatest draught of tugs was 11 feet, of barges 9 feet, and of sailing vessels 10 feet. A large number of sail-vessels is engaged in carrying wood, lumber, grain, and oysters upon the lower part of the river. Their number could not be ascertained.

The number of arrivals of sail-vessels, with greatest draught of 10 feet, at points above Tappahannock, is stated at 50 per year; at Tappahannock it is stated to be 100 per year; below Tappahannock the number is much larger. The value of shipments and receipts at Tappahannock in 1889 is reported to be $356,700. This does not represent the value of the trade passing over the bar just above this point. Concerning this bar, Mr. Thomas Croxton, a former Representative in Congress from the district containing this river, makes the following statement in a letter dated November 16, 1889:

"The obstruction at Naylor's Hole, if not removed, will block the river from there to the city of Fredericksburg. Between these places there are not less than ten important landings with wharves."

Two side-wheel steamers of the Weems Line ply from Fredericksburg and the river landings to Baltimore, and one propeller runs from Fredericksburg to Norfolk.

At each of the landings from Fredericksburg to Naylor's Hole, during most of the year, the steamers of the Weems Line carrying the mails arrive twice per week from Baltimore and twice from Norfolk. At Naylor's Hole, about 60 miles below Fredericksburg, and at the landings below, there are three arrivals of the same steamers from Baltimore and two from Norfolk each week.

TONNAGE.

	Tons.
In 1888, 5 tugs and 18 barges carried	48,600
In 1888, the Weems Line carried	35,000
Total	83,600

INCREASE IN TONNAGE.

The agent of the Weems Line reports the tonnage for 1889 about the same as in 1888, viz, 35,000 tons. The total tonnage of this line in 1881 was 12,000 tons. (See Report for 1883, page 813). Increase, 23,000 tons.

No statement can be made of the increase in tonnage of the other lines of transportation.

It is to be borne in mind that no report could be obtained from the large number of sail vessels trading on the lower part of the river.

IMPROVEMENT OF RAPPAHANNOCK RIVER, VIRGINIA, AT URBANA CREEK, A TIDAL TRIBUTARY THEREOF.

HISTORY OF OPERATIONS.

For "Reference to reports" and "Description of original condition" see Report of Chief of Engineers for 1888, Part II, page 825. For "Plan of improvement" see Report of Chief of Engineers for 1889, Part II, page 1009.

WORK DONE DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

(*a*) *Work by contract.*—No bids for dredging having been received on May 6, 1889, and two informal bids for dike construction, opened on the 6th of May, 1889, having been rejected as excessive, advertisements were again issued on July 30, 1889. No bids for dike construction were received on August 28, the day fixed for opening proposals.

The American Dredging Company submitted a bid for dredging at 19 cents per cubic yard. This was the only bid received, and contract was awarded to this company.

Work began on October 28, 1889, and closed on the 4th of November following.

Dredging was done at the end of the spit on the east side of the channel, and at the turn just below on the same side.

The channel past the spit is about 120 feet in width, and at the turn it is now about 300 feet wide, making the navigation less difficult for steamers. At the entrance into the Rappahannock the channel is, as before, about 90 feet wide. The depth in the channel is from 9 to 10 feet outside of the spit. Within the harbor the width and depth remain as before, viz, from 9 to 10 feet deep, and not less than 80 feet wide.

Under this contract 8,069 cubic yards were dredged.

(*b*) *Work by hired labor.*—Two dikes or sand fences were constructed, one on the inside of the spit about 80 feet in length; the other on the outside about 160 feet in length. These dikes correspond in position with dikes marked C and D on the chart of last year. Old brush wattling 212 feet long (on the spit) was repaired. The object of this work is to arrest the movement of sand, and to prevent the formation of a new inlet or mouth.

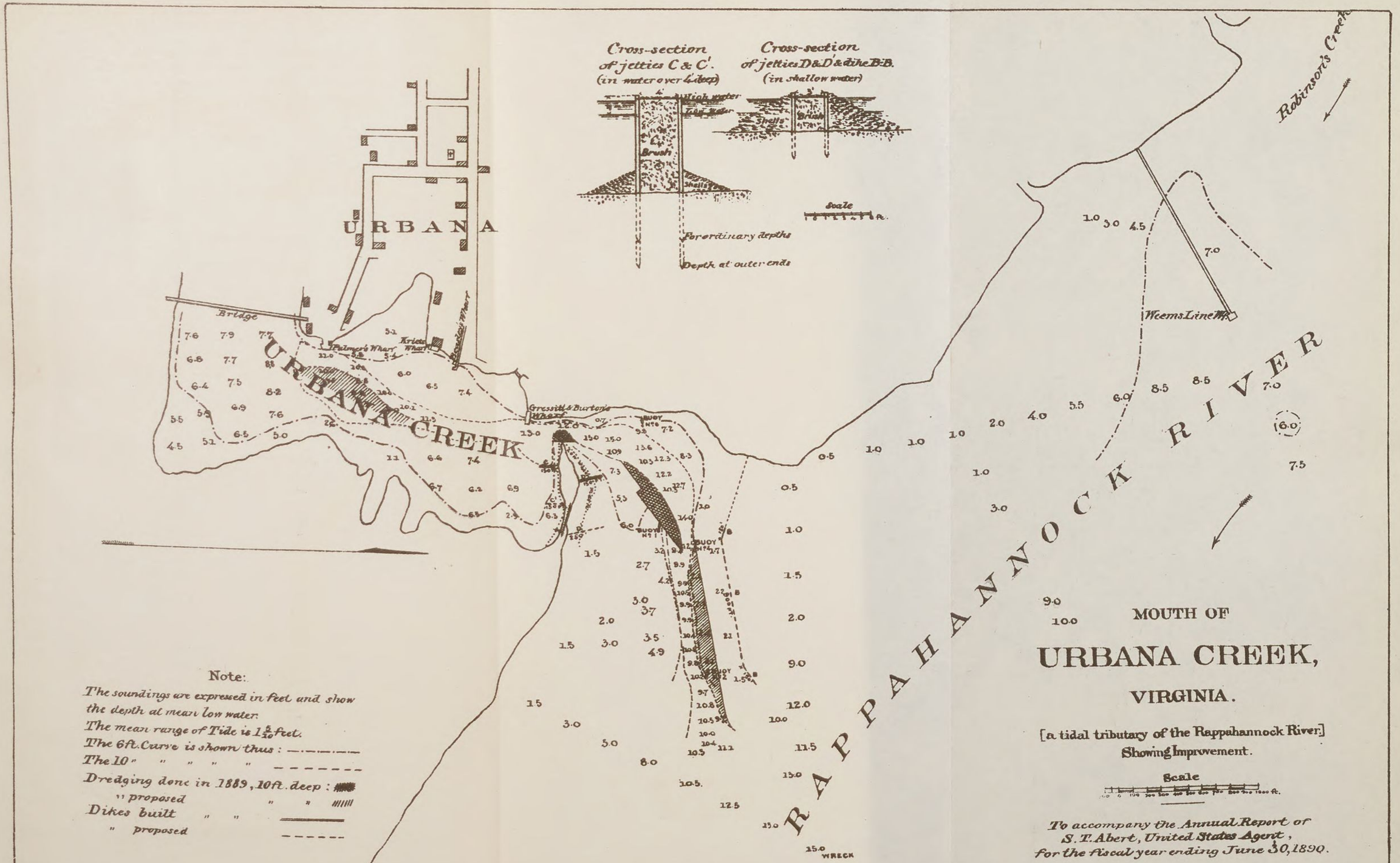
AMOUNT EXPENDED AND RESULTS OBTAINED TO JUNE 30, 1890.

Since the first appropriation, March 3, 1879, $18,500 have been expended in dredging 23,798 cubic yards, at prices varying from 15 to 30 cents per yard; in building a wattled dike, and two sand fences.

The channel outside the spit, or mouth, varies from 90 to 300 feet in width, and the channel in the inner harbor retains its depth and width. The depth in all these channels varies from 9 to 10 feet. The bend in the channel outside just below the spit is declared to be difficult, if not dangerous, when the wind is from the northeast or northwest. The pilots of steamers are opposed to entering the harbor, and prefer to make their landings at the wharf of the Weems Line in Rappahannock River, nearly a mile distant from Urbana.

FUTURE OPERATIONS.

Work proposed under the project submitted December 5, 1888.—Two small dikes have been constructed, about one-eighth of all projected,



Note:

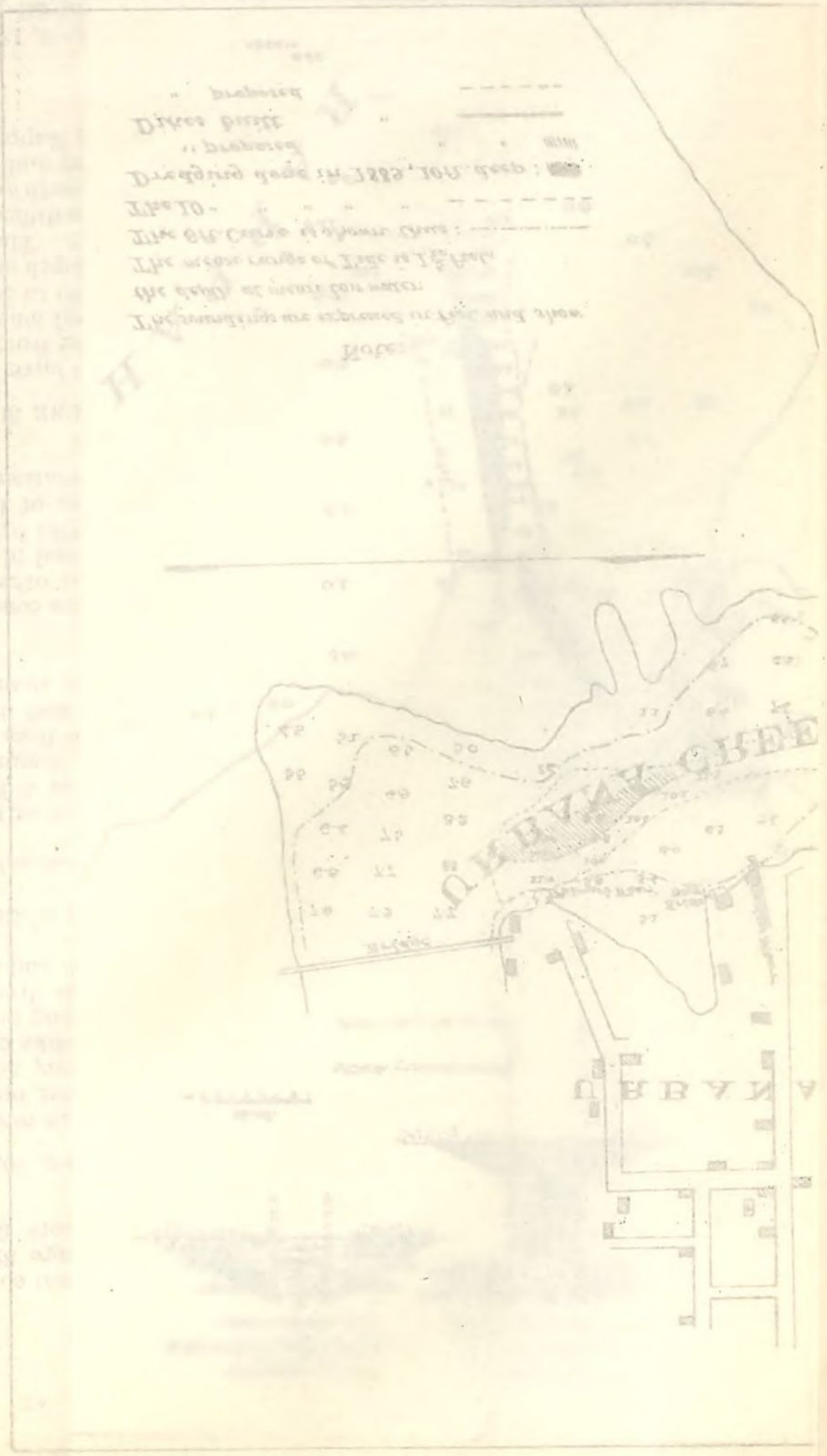
The soundings are expressed in feet and show the depth at mean low water.
The mean range of Tide is 1 5/10 feet.
The 6ft. Curve is shown thus: —·—·—
The 10" " " " " — — — — —
Dredging done in 1889, 10ft. deep: ▪▪▪
" proposed " " ////////
Dikes built " " ———
" proposed — — — —

MOUTH OF URBANA CREEK, VIRGINIA.

[a tidal tributary of the Rappahannock River]
Showing Improvement.

Scale

To accompany the Annual Report of S. T. Abert, United States Agent, for the fiscal year ending June 30, 1890.



and about one-eighth of the dredging was executed, thus leaving about seven-eighths of each class of work under the project.

The estimate of 1888 amounted to $19,080.

The following appropriations have been made:

March 3, 1879	$5,000
June 14, 1880	2,500
March 3, 1881	4,000
August 2, 1882	4,000
August 11, 1888 (included in appropriation of $15,000 for Rappahannock River)	3,000
Total	18,500

Urbana is a port of entry in the collection district of Tappahannock.

A chart showing the work done during the fiscal year ending June 30, 1890, accompanies this report.

Money statement.

July 1, 1889, amount available	$2,850.00
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	2,850.00
Amount appropriated by act of September 19, 1890	3,000.00
Amount (estimated) required for completion of existing project	13,080.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	13,080.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

STATISTICS OF TRADE.

Mr. F. A. Bristow reports the total value of the trade by water, in natural products, $162,000, consisting principally of fish and oysters, bacon, grain, railroad-ties, and wood; and of manufactures, $76,050; total, $238,050. Of this $100,000 worth is carried by six sail-vessels whose greatest depth is 10 feet. As an effect of work thus far done he reports: "Larger vessels enter our port, and we have opened trade with New York." As to advantages to be derived from completion of the proposed improvement, he says: "Steamers land 1½ miles from us. We wish to make the channel straighter so as to enable the steamers to come into our creek. We think this can be done at a moderate cost to the Government." The amount of business done in 1889 by fourteen business houses is reported to be about $75,000; and the following statement is made: "There are two large carriage factories at Saluda (about 4 miles from Urbana) that land their goods here. Our country is raising more hay and improved stock, and our people are dealing more largely in wood, railroad-ties, lumber, etc. We are anxious to get the steamers into our creek, which is a good landing and more convenient for the people in all this section."

L 7.

IMPROVEMENT OF TOTUSKY RIVER, VIRGINIA.

HISTORY OF OPERATIONS.

For "Reference to report," "Description of original condition," and "Plan of improvement" see Report of Chief of Engineers for 1888, Part II, page 824.

Nothing was done during the year for lack of funds. If no appropriation be made for the next fiscal year, I would respectfully recommend that this improvement be dropped.

The following appropriations have been made:

June 14, 1880	$2,500
March 3, 1881	2,500
August 2, 1882	5,000
Total	10,000

The work is in the collection district of Tappahannock, the nearest port of entry. The nearest light-house is Bowler's Rock, in the fifth light-house district.

Money statement.

Amount (estimated) required for completion of existing project	$12,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

STATISTICS OF TRADE.

See Report of Chief of Engineers for 1889, Part II, page 1012. No statement for the year 1889 has been received.

L 8.

IMPROVEMENT OF MATTAPONI RIVER, VIRGINIA.

HISTORY OF OPERATIONS.

For "Reference to reports," "Description of original condition," and "Plan of improvement," see Report of Chief of Engineers for 1888, Part II, pages 826 and 827.

WORK DONE DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

The construction, by hired labor, of dikes at Robinson's Bar, in progress at the close of the last fiscal year, was continued until August 22, when work was stopped, the funds being exhausted.

The dikes partially built at the close of the last fiscal year were finished, and 243 linear feet of dike in addition were completed. The plant used for this work, belonging to the Rappahannock River, and consisting of combined steam hoister and pile-driver, lighter and necessary tools, was transferred on August 23 to the Pamunky River for work on that improvement.

AMOUNT EXPENDED AND RESULTS OBTAINED TO JUNE 30, 1890.

From the year 1880 to June 30, 1890, $16,300 have been expended in removing snags, overhanging trees, and wrecks from Mundy's Bridge to Robinson's Bar, a distance of 34 miles; in constructing 1,999 linear feet of sheet-pile dike and 227 linear feet of pile and brush dike at Robinson's Bar; in sinking 29 mats in front of the dike; and in driving 7 clusters of fender-piles.

FUTURE OPERATIONS.

The remainder of the dikes proposed at Robinson's Bar and those proposed for Latané's Bar should be built and channels should be dredged through the bars parallel to them. Four bars between Robinson's and Ayletts, the worst of which is Walker's Bar, and two bars be-

tween Walkerton and West Point, viz, Walkerton and Yew Grove bars, are reported to require improvement. The small amount of funds appropriated has never permitted an instrumental survey to be made.

Snags and fallen and overhanging trees accumulate each year and require removal to prevent obstruction to navigation.

The following appropriations have been made:

June 14, 1880	$2,500
March 3, 1881	3,300
July 5, 1884	2,500
August 5, 1886	5,000
August 11, 1888	3,000
Total	16,300

The work is in the collection district of Richmond, the nearest port of entry. The nearest light-house is Bell Rock.

Money statement.

July 1, 1889, amount available		$2,070.16
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	2,067.05	
July 1, 1890, outstanding liabilities	3.11	
		2,070.16
Amount appropriated by act of September 19, 1890		3,000.00
Amount (estimated) required for completion of existing project		52,800.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		15,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

STATISTICS OF TRADE.

No complete statement of the whole river has been obtained since that for 1884, published in the Report for 1885, Appendix K, page 981, which was furnished by Capt. B. F. Eaton. The totals of that statement are as follows:

Value natural products	$419,700
Value manufactures	231,000
Total	650,700

The amount of business in mills, factories, etc., was $338,000.

There were 542 vessels engaged in trade with a total tonnage of 105,884 tons.

For details see Report for 1885.

Mr. J. G. Dew reports the value of trade on the upper part of the river for 1889 $167,400, and states that there is a number of local grist-mills, and that country stores every few miles do a large business and for the most part control the grain of the country; that there are occasional sail-vessels, 12 or 15 flat-boats, and a great number of rafts.

Mr. Dew makes the following statements:

"A very large part of the produce of the country adjacent to Dunkirk and Aylett's is now marketed by wagon or shipped by rail at great inconvenience.

"Dunkirk and Aylett's were, in colonial times, trading posts with English and other vessels; and were warehouse towns for the storage and shipment of tobacco. Now the river has so filled up and has been so blockaded that it is very difficult to get small vessels to venture so high up the stream.

"The lack of proper public facilities on the river has greatly retarded the recuperation and development of this section. * * *

"The people can not bear the expense [of opening up the river] and they can not build a railroad. Hence we can only ask for a just appropriation at the hands of Congress."

The value of trade given by Mr. Dew for 1888 Report for 1889, Appendix I, page 1013) should be $209,100.

L 9.

IMPROVEMENT OF PAMUNKY RIVER, VIRGINIA.

HISTORY OF OPERATIONS.

For "Reference to reports," "Description of original condition," and "Plan of improvement" see Report of Chief of Engineers for 1888, Part II, pages 828 and 829.

WORK DONE DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

Work by hired labor.—(1) The river was cleared of dangerous snags, logs, and sunken and overhanging trees from New Castle Ferry to below Garlick's Ferry, a distance of about 15 miles.

There were removed 19 trees, 6 drift-logs, and 65 snags.

The dike at Skidmore's Bar, injured by freshets, was repaired, and two mats were replaced in front of dike at Spring Bar.

The above work was done with the Rappahannock plant between August 23 and September 19, 1889. The plant consisted of a combined steam-hoister and pile-driver supplied with side-wheels, and of lighters, and necessary tools. Three hundred and seventy-two dollars were expended for the work.

(2) In December, 1889, and January, 1890, 566½ linear feet of pile and brush dike were built at Skidmore's Bar to protect the bank damaged by the wreck of the *Americus*. Two hundred dollars were expended in this work.

Work by contract.—Bids opened in May, 1889, were rejected. Following is an abstract of proposals opened August 28, 1889:

No.	Name and address of bidder.	Commence.	Complete.	Price.
				Cents.
1	American Dredging Company, Philadelphia, Pa.....	Jan. 6, 1890	Feb. 8, 1890	19
2	Thomas P. Morgan, Washington, D. C	Nov. 15, 1889	Dec. 20, 1889	25

Contract with American Dredging Company.

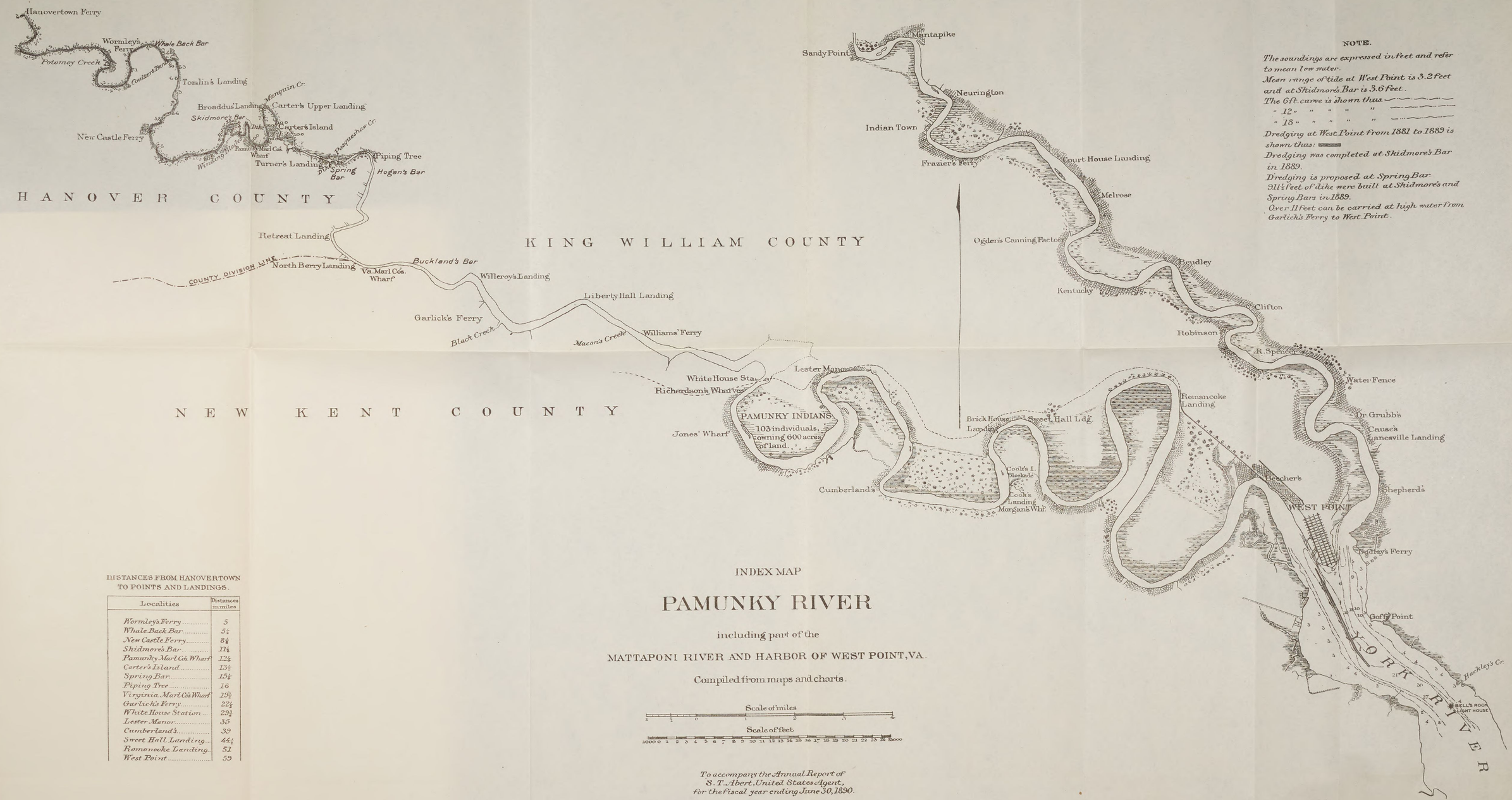
Work commenced November 15 and was completed December 5, 1889.

A channel 6 feet deep at low water, 95 feet wide, and about 800 feet long was dredged through Skidmore's Bar. The center cut of this channel was made 7 feet deep and 35 feet wide. The dredging proposed at this bar was completed, 8,076 cubic yards having been removed under this contract.

AMOUNT EXPENDED AND RESULTS OBTAINED TO JUNE 30, 1890.

To June 30, 1890, $15,490.83 have been expended in removing snags and overhanging trees from Hanovertown to Garlick's Ferry, a distance of 22½ miles; in removing parts of the following wrecks which obstructed navigation, viz: Three at Skidmore's Bar, three at Carter's Island, and one at White House; and in the construction of 911½ feet of dike at Skidmore's and Spring bars.

A channel has been dredged through Skidmore's Bar 6 feet deep low water, 95 feet wide, and about 800 feet long. The center cut made 7 feet deep and 35 feet wide.



NOTE.

The soundings are expressed in feet and refer to mean low water.
Mean range of tide at West Point is 3.2 feet and at Skidmore's Bar is 3.6 feet.
The 6ft. curve is shown thus ——·——·——
" 12" " " " " ——··——··——
" 18" " " " " ——···——···——
Dredging at West Point from 1881 to 1889 is shown thus: ▬▬
Dredging was completed at Skidmore's Bar in 1889.
Dredging is proposed at Spring Bar.
911 feet of dike were built at Skidmore's and Spring Bars in 1889.
Over 11 feet can be carried at high water from Garlick's Ferry to West Point.

DISTANCES FROM HANOVERTOWN TO POINTS AND LANDINGS.

Localities	Distances in miles
Wormley's Ferry	5
Whale Back Bar	5½
New Castle Ferry	8½
Skidmore's Bar	11⅛
Pamunky Marl Cos Wharf	12¼
Carter's Island	13½
Spring Bar	15¼
Piping Tree	16
Virginia Marl Cos Wharf	19½
Garlick's Ferry	22½
White House Station	29⅜
Lester Manor	35
Cumberland's	39
Sweet Hall Landing	44½
Romancoke Landing	51
West Point	59

INDEX MAP

PAMUNKY RIVER

including part of the

MATTAPONI RIVER AND HARBOR OF WEST POINT, VA.

Compiled from maps and charts.

Scale of miles
1 ½ 0 1 2 3 4

Scale of feet
1000 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 2000

To accompany the Annual Report of S. T. Abert, United States Agent, for the fiscal year ending June 30, 1890.

FUTURE OPERATIONS.

The channel through Spring Bar requires dredging.

For want of funds, instrumental surveys have been made of Skidmore's and Spring bars only, where improvement has seemed to be most needed for benefit of trade.

After the improvement of Spring Bar no very serious obstructions to navigation are believed to exist, though four bars have been reported as requiring some improvement.

Fallen trees and snags accumulate each year, and their removal is required to prevent obstructions to navigation. The plant belonging to Rappahannock River has been used for this object.

The following appropriations have been made:

June 14, 1880	$2,500
March 3, 1881	2,500
August 2, 1882	2,500
August 5, 1886	5,000
August 11, 1888	3,000
Total	15,500

The work is in the collection district of Richmond, the nearest port of entry.

The following drawing accompanies this report:

General map of the whole river.

Money statement.

July 1, 1889, amount available		$2,857.98
February 18, 1890*, cash deposited with Treasurer United States		4.46
		2,862.44
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$2,846.08	
July 1, 1890, outstanding liabilities	7.19	
		2,853.27
July 1, 1890, balance available		9.17
Amount appropriated by act of September 19, 1890		3,000.00
Amount available for fiscal year ending June 30, 1891		3,009.17
Amount (estimated) required for completion of existing project		10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1892		10,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

STATISTICS OF TRADE.

No satisfactory statement of trade has ever been obtained; and none has been received since 1888 in reply to requests for statistics addressed to parties interested.

*Sums for which receipts were obtained on pay-rolls and credit claimed in accounts of previous years, but not actually disbursed because of absence on pay-day of employés by whom earned and the subsequent inability to find the men after repeated efforts. Authority for deposit and full explanation filed with account current for February, 1890.

L 10.

IMPROVEMENT OF YORK RIVER, VIRGINIA.

HISTORY OF OPERATIONS.

For "Reference to reports," "Description of original condition," and "Plan of improvement" see Report of Chief of Engineers for 1888, Part II, pages 830 and 831.

WORK DONE DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

No dredging has been done since February, 1889, when the contract for dredging at West Point, under the appropriation of August 11, 1888, was completed.

An examination of the channel in January, 1890, indicated that the deposit of silt at West Point Bar is between 2 and 3 feet deep in one year, and previous observations indicate that silting will continue until the depth on the bar is reduced to 15½ feet unless the accumulation of sand and mud is removed by dredging or is prevented by the construction of longitudinal dikes built parallel with the channel.

The examination indicated that the deposit at Potopotank Bar is much less rapid than at West Point, it being between 2 and 3 feet in nine years.

AMOUNT EXPENDED AND RESULTS OBTAINED TO JUNE 30, 1890.

At Potopotank Creek, 58,809 cubic yards of material were dredged in 1880–'81, at the rate of 15 cents per cubic yard, which gave a channel 105 feet wide and 22 feet deep.

The depth of the channel in January 1890 varied from 20.8 feet to 21.7 feet at mean low water. The ruling depth before improvement was 18½ feet.

At West Point, 795,704 cubic yards were dredged under successive appropriations between October 4, 1881, and June 30, 1889, at rates varying from 8½ to 16 cents, which gave the channel through the bar a width varying from 161 to 257 feet, and a depth, exclusive of the center cut, of not less than 22 feet at mean low water for a distance of about 11,450 feet. The depth in January 1890, not including the center cut, varied from 19 to 24.7 feet. The ruling depth before improvement was 15½ feet.

Under a modification of the project by the Secretary of War, January 4, 1889, a cut 40 feet wide and 24 feet deep at low water was dredged near the center-line of the channel, beginning at the upper end of the bar, opposite the lower wharf at West Point, and extending to the second turn in the channel, a distance of about 12,120 feet.

It was intended to make the width of this center cut 80 feet, but work had so far progressed with the 22-foot depth of channel under the original project before the modification was authorized that the funds permitted only one cut 40 feet wide to be made.

The ruling depth in this cut in January, 1890, was 20.6 feet.

Since the commencement of the work at West Point in 1881 it has been necessary to redredge 152,595 cubic yards of silting, which was not provided for in the original estimate. This is about one-fifth (nineteen one-hundredths) of the whole amount dredged at West Point.

The amount expended to June 30, 1890, is $127,489.27

FUTURE OPERATIONS.

Work to be done to complete the original project will consist in widening the channel at West Point Bar and the bar at Potopotank Creek to 400 feet, with a depth of 22 feet at low water.

The following appropriations have been made:

June 14, 1880	$10,000
March 3, 1881	25,000
August 2, 1882	25,000
July 5, 1884	20,000
August 5, 1886	18,750
August 11, 1888	30,000
Total	128,750

The original estimate is $256,000.

The work is in the collection district of Richmond, Va., which is the nearest port of entry. The nearest light-house is Bell Rock, in the fifth light-house district.

Money statement.

July 1, 1889, amount available		$2,439.05
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$1,138.32	
July 1, 1890, outstanding liabilities	40.00	
		1,178.32
July 1, 1890, balance available		1,260.73
Amount appropriated by act of September 19, 1890		30,000.00
Amount available for fiscal year ending June 30, 1891		31,260.73
Amount (estimated) required for completion of existing project		97,250.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		67,250.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

STATISTICS OF TRADE.

The following letter and statement of trade were received from the agent of the Piedmont Air Line:

WEST POINT, VA., *May* 1, 1890.

DEAR SIR: In compliance with your request of 18th of April, we beg to inclose statement requested, and regret we are unable to give you draughts off he vessels, for the reason that our record for last year does not give this information. In future we will be able to furnish this information, as we have made arrangements to compile same for future use.

Yours, truly,

E. T. LAMB,
General Forwarding Agent.

S. T. ABERT,
United States Agent.

PIEDMONT AIR LINE.

Statement showing volume of business via West Point, Va., for calendar year 1889.

Tonnage to and from Mattaponi River Landings:		
Steam crafts		105
Tonnage		12,600
Draught	feet..	8
Coastwise tonnage:		
Steam-ships		555
Tonnage		785,124
Schooners		74
Tonnage		9,585
Total number of coastwise vessels from Eastern cities		629
Carrying capacity of same in tons		794,709

Foreign tonnage:		
Steam-ships		41
Tonnage		97,103
Barks		7
Tonnage		4,678
Total number of vessels to foreign ports		48
Carrying capacity of same in tons		101,871
Total tonnage:		
Steam-ships		701
Tonnage		894,827
Barks		7
Tonnage		4,768
Schooners		74
Tonnage		9,585
Total number of vessels loaded at this port		782
Carrying capacity of same in tons		909,180
North-bound tonnage:		
Merchandise	tons	82,229
Iron	do	26,157
Cotton—bales, 159,751	do	38,340
Lumber	do	3,164
Total North-bound tonnage	do	149,890
South-bound tonnage:		
Merchandise	do	105,998
Guano	do	12,327
Salt	do	5,069
Total South-bound	do	123,394
Foreign tonnage:		
Cotton—bales, 220,386	do	53,286
Cattle—head, 852	do	596
Oil-cake	do	570
Bark	do	79
Staves	do	143
Flour	do	133
Merchandise	do	257
Total foreign	do	55,072
Handled:		
North-bound	pounds	299,769,596
South-bound	do	246,789,959
Foreign	do	110,145,728
Total	do	656,705,283
Total	tons	328,353
Cotton handled	bales	380,137
	tons	91,626
Guano handled	do	12,327
Salt handled	do	5,069

INCREASE IN TONNAGE.

	Tons.
Total tonnage reported above for 1889	328,353
Total tonnage reported for 1888	285,480
Increase	42,873

Under date of February 10, 1888, Mr. P. H. Adams, at that time agent of Piedmont Air Line, reported that the foreign tonnage for 1887 was thirty times as great as for 1880, while the coastwise tonnage was four times as great.

The following letter from Mr. Lamb gives the proportionate increase for the year 1889:

WEST POINT, *May* 14, 1890.

DEAR SIR: In reply to yours of the 12th instant, we beg to say that the 12,600 tons reported forwarded to Mattaponi River landings should be added to York River tonnage, as the freight was carried on said river.

The foreign tonnage is ninety times greater than it was in 1880. During that year we only did foreign business to South American ports in flour, whereas now the greater amount of north-bound business handled here is for foreign ports.

The coastwise tonnage is about five times greater than it was in 1880. Of course you ask for an approximation, and this estimate our judgment believes to be correct.

We are trying now to get a statement showing tonnage for Mataponi and Pamunky rivers, and as soon as this information is in such a state as to be tabulated we will give you results of our efforts.

Yours truly,

E. T. LAMB,
General Forwarding Agent.

L 11.

IMPROVEMENT OF CHICKAHOMINY RIVER, VIRGINIA.

HISTORY OF OPERATIONS.

For "Reference to reports," "Description of original condition," "Plan of improvement," and "Table of distances," see Report of Chief of Engineers for 1889, Part II, page 1018.

WORK DONE DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

The contract with the American Dredging Company for dredging 11,098 cubic yards from Binn's and Old Fort bars was begun at Binn's Bar on June 15, 1889, and was concluded at old Fort Bar on July 1, 1889. The work at Old Fort Bar was done at Lower Old Fort, and was upon a part of the bar which had never been dredged before.

AMOUNT EXPENDED AND RESULTS OBTAINED TO JUNE 30, 1890.

To June 30, 1890, $12,500 have been expended at Windsor Shades, Old Fort, and Binn's bars, and $9,000 at the mouth of the river, making a total of $21,500. With this sum 56,197 cubic yards have been removed from Windsor Shades, Old Fort, and Binn's bars at rates varying from 14 to $14\frac{8}{10}$ cents per cubic yard; and 38,158 cubic yards have been removed from the bar at the mouth of the river at rates varying from $14\frac{5}{8}$ to $22\frac{1}{2}$ cents per cubic yard. Channels have been dredged of the following dimensions: At Windsor Shades, 100 feet wide and from 8 to 9 feet deep at low water; at Old Fort, 100 feet wide and from 8 to $9\frac{1}{2}$ feet deep; and at Lower Old Fort, sometimes called Osborne's Bar, a channel was dredged in 1889 from 30 to 60 feet wide and 9 feet deep at low water. This was the first dredging done at Lower Old Fort. At Binn's Bar the channel was dredged, in 1879 and 1880, 200 feet wide and from $7\frac{1}{2}$ to $8\frac{1}{2}$ feet deep through the lower part of the bar, and during the last fiscal year, in June, 1889, the upper part of this bar was dredged for the first time to a depth of 9 feet. The width of this cut was 60 feet, and the length about 1,500 feet.

In 1886 a channel was made through the bar at the mouth of the river with a width of 200 feet, a depth of from 14 to 15 feet at low water, and a length of from 1,700 to 1,800 feet, with a fan-shaped cut at the upper end, giving a maximum width of 250 feet.

An examination of the upper bars, made in October, 1888, showed that the depths, except at Old Fort Bar, remained nearly as when dredged; that at Old Fort Bar the first channel dredged had filled slightly,

which is probably due to sudden bends above and below it, and to the cross-currents caused thereby; and that the channels at Windsor Shades and at Old Fort bars have been reduced in width, probably by filling from the sides of the cuts.

FUTURE OPERATIONS.

The amount due on the original estimate should be expended in widening the cuts already made at the several bars to the full widths provided for in the project.

The recent cuts at Old Fort and Binn's bars should be widened to 100 feet. The original cuts at Windsor Shades and Old Fort bars require widening where filled at the sides.

The following appropriations have been made:

June 18, 1878	$5,000
March 3, 1879	1,000
June 14, 1880	2,000
March 3, 1881	2,000
August 2, 1882	5,000
August 5, 1886	4,000
August 11, 1888	2,500
Total	21,500

The work is in the collection district of Richmond, the nearest port of entry. The nearest light-house is Deep-Water Shoal light-house in the fifth light-house district.

Money statement.

July 1, 1889, amount available	$477.82
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	477.82
Amount appropriated by act of September 19, 1890	2,500.00
Amount (estimated) required for completion of existing project	7,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	7,500.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

STATISTICS OF TRADE.

Mr. L. F. Barnes makes the following statement of trade for 1889:

Natural products, wood, railroad ties, sawed lumber, logs, etc, (of this $80,500 was trade by rail) valued at	$1,176,500
Manufactures, groceries, agricultural-machines, hardware, etc. (of which $223,000 was trade by rail)	365,500
Total	1,542,000

He reports "about 26 general merchandise stores, 6 saw-mills, and 10 grist-mills. Amount of business, $1,600,000."

The total value of freight transported by vessels is stated to be $1,238,500, carried by 5 steamers, 200 sail-vessels, 25 barges, 6 canal-boats, and 550 flat boats; total number of vessels, 736.

The effect of work thus far executed is that "vessels are much easier to command, freights are less. Before the improvement of the river commenced, it was with the greatest difficulty that we could get vessels; in fact we could not get them at the head of navigation, Windsor Shades, to which point we want at least 12 feet of water to enable us to compete with other lines."

The completion of the proposed improvement "will be of unlimited advantage to commerce and will open up the whole section of country to the markets of the world, thus enabling the farmers to introduce a variety of crops."

TONNAGE.

Mr. Barnes gives the amount of freight for the calendar year 1889, 37,226,250 pounds, or 18,613 tons, valued at $1,238,500, as reported in his previous statement given above.

L. 12.

IMRPOVEMENT OF STAUNTON RIVER, VIRGINIA, BETWEEN BROOK NEAL AND RANDOLPH STATION.

HISTORY OF OPERATIONS.

For "Reference to reports," "Description of original condition," and "Plan of improvement," see Report of Chief of Engineers for 1888, Part II, Pages 834 and 835.

WORK DONE DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

Under appropriation of August 11, 1888, work was closed on October 18, 1889.

The construction of crib-dams was continued at White Rock Falls, about 2 miles below Brook Neal, as far as the high water would permit. Two dams were lengthened and two dams nearly completed; 144 cubic yards of stone were blasted, and 30 yards were removed from the channel. Delay, and suspension of the work on October 18, 1889, were necessitated by the unusually high water.

The water was unusually high through the working season.

AMOUNT EXPENDED AND RESULTS OBTAINED TO JUNE 30, 1890.

To this date $37,314.53 have been expended.

This expenditure has resulted in making about 29½ miles of the river navigable for small steamers.

The channel at White Rock Falls is now passable by steamers, but the number of dams designed has not been completed.

FUTURE OPERATIONS.

The excavation of some rock from the channel between Brook Neal and White Rock Falls; the removal of débris left in the channel between Brook Neal and Randolph, the two termini, and the construction of scouring-dams where needed will complete this improvement. There are still $31,200 due on the estimate, which, it is believed, will be sufficient to complete the work if appropriated in one sum. The improvement has been in progress for ten years.

REMARKS.

The mean level of the water-surface during six or seven months of the year is from 2 to 3 feet above low water, which gives a depth in the excavated channel during this period of from 4 to 5 feet.

The following appropriations have been made:

March 3, 1879	$5,000
June 14, 1880	7,500
March 3, 1881	5,000
August 2, 1882	5,000
July 5, 1884	5,000
August 5, 1886	5,000
August 11, 1888	5,000
Total	37,500

Money statement.

July 1, 1889, amount available		$2,465.82
February 18, 1890,* cash deposited with Treasurer United States		21.02
		2,486.84
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$2,280.35	
July 1, 1890, outstanding liabilities	21.02	
		2,301.37
July 1, 1890, balance available		185.47
Amount appropriated by act of September 19, 1890		8,000.00
Amount available for fiscal year ending June 30, 1891		8,185.47
Amount (estimated) required for completion of existing project		23,200.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		23,200.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

STATISTICS OF TRADE.

Mr. Charles Bruce, of Cole's Ferry, writes as follows, under date of November 16, 1889:

"I regret very much that it is utterly impossible for me to give any estimates of the Staunton River trade. The present year, however, it must be inconsiderable, as the whole valley has been repeatedly swept by floods and all crops within reach of the water destroyed.

"With the completion of the Lynchburg and Durham road, the river promises to be a very important channel of communication between that and the Danville road, and already we have a steamer well adapted to the navigation. It is very important, I think, that the Government should make a further appropriation for the improvement of the river in order to prevent the formation of sand-bars at low water, which are still serious obstructions to navigation in the summer season."

Citizens of Brook Neal and of Cole's Ferry were requested to furnish statistics. Messrs. Pringle Bros., Lawson & Walthall, and Evans & Robertson, all of Brook Neal, responded that the improvement being not yet completed to Brook Neal, it was impossible for them to give any estimate of the value of products shipped; that it will give a nearer and cheaper route to Richmond and Danville markets and will be of great advantage in shipping tobacco, sumac, wheat, corn, bark, lumber, and many other kinds of produce.

No statistics were received from Cole's Ferry.

BETWEEN PIG RIVER AND BROOK NEAL.

HISTORY OF OPERATIONS.

For "Reference to reports," "Description of original condition," and "Plan of improvement," see Report of Chief of Engineers for 1888, Part II, pages 836 and 837.

WORK DONE DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

Nothing done for lack of funds.

*Sums for which receipts were obtained on pay-rolls and credit claimed in accounts of previous years, but not actually disbursed because of absence on pay-day of employés by whom earned, and the subsequent inability to find the men after repeated efforts. Authority for deposit and full explanation filed with account current for February, 1890.

AMOUNT EXPENDED AND RESULTS OBTAINED TO JUNE 30, 1890.

The amount expended to date is $7,000.

A channel 14 feet wide and 1½ feet deep has been opened from the Virginia Midland Railroad Bridge to a point 18½ miles above. One thousand two hundred and sixty-seven cubic yards of blasted rock and 330 cubic yards of loose rock have been removed.

FUTURE OPERATIONS.

The completion of rock excavation to Pig River, 5 miles, and the construction of dams to reduce the slope of the water surface at various points are still required under the project.

No work has been done on the river between the Virginia Midland crossing and Brook Neal, a distance of about 28½ miles.

The following appropriations have been made:

August 2, 1882	$2,000
August 5, 1886	5,000
Total	7,000

Money statement.

February 18, 1890,* cash deposited with Treasurer United States	$13.72
July 1, 1890, outstanding liabilities	13.72
Amount (estimated) required for completion of existing project	27,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	13,500.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

STATISTICS OF TRADE.

Mr. John L. Hurt reports value of trade by water:

Ores	$5,000

Value of trade by rail:

Natural products	37,800
Manufactures	12,500
Total	55,300

In addition to the above, he says a large quantity of lumber and several car-loads of sumac were shipped.

L 13.

IMPROVEMENT OF DAN RIVER, VIRGINIA AND NORTH CAROLINA.

HISTORY OF OPERATIONS.

For "reference to reports," "description of original condition," and "plan of improvement," see Report of Chief of Engineers for 1888, Part II, page 838.

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* Sums for which receipts were obtained on pay-rolls and credit claimed in accounts of previous years but not actually disbursed because of absence on pay-day of employés by whom earned, and the subsequent inability to find the men after repeated efforts. Authority for deposit and full explanation filed with account current for February, 1890.

WORK DONE DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

Nothing done during the year. Active operations were suspended on July 13, 1888, for lack of funds, and the plant was sold in August of the same year.

AMOUNT EXPENDED AND RESULTS OBTAINED TO JUNE 30, 1890.

To June 30, 1890, $50,500 were expended. For results obtained, see Report for 1889, page 1024. Nothing done since July 1888.

FUTURE OPERATIONS.

See Report of Chief of Engineers for 1888, Part II, page 839.

The following appropriations have been made:

June 14, 1880	$10,000
March 3, 1881	8,000
August 2, 1882	7,500
July 5, 1884	5,000
August 5, 1886	20,000
Total	50,500

Money statement.

February 18, 1890, *cash deposited with Treasurer of the United States	$39.63
July 1, 1890, outstanding liabilities	39.63
Amount (estimated) required for completion of existing project. Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	7,000.00

STATISTICS OF TRADE.

The following letter, dated November 25, 1889, was received from Mr. J. W. Gallaway, mayor of Madison:

"We have had no statistics of trade, for it was all done by wagon.

"Leaksville, Madison, and Walnut Cove are the three principal trading points for the North Carolina Dan River Valley. Until very recently they have been without steam communication, and their trade has been carried on wagons to and from Greensboro, Winston, and Danville. For the past eight or ten months they have all three had rail communication with the outside world. The Madison depot shows an average freight business of 66,000 pounds per month sent off, and 66,000 pounds received, and is rapidly increasing. The same may be said of Walnut Cove and Leaksville, as many industries spring up in a community long isolated and now restored to companionship with the world.

"Our principal exports are tobacco and lumber. Mines of mica and slate will now be operated.

"We send off dried fruits, sumac, etc., but these are make-weights."

Dr. Thomas L. Sydnor, of Danville, reports that there is no trade by water.

L 14.

REMOVING SUNKEN VESSELS OR CRAFT OBSTRUCTING OR ENDANGERING NAVIGATION.

HISTORY OF OPERATIONS.

(1) *Wreck in Pamunky River, Virginia.*—Removal of the wrecked barge *Amicus*, upon which work was in progress at the close of the fiscal year ending June 30, 1889, was completed in October, 1889, under contract with James H. and Charles H. Denmead for $800.

*Sums for which receipts were obtained on pay-rolls and credit claimed in accounts of previous years, but not actually disbursed because of absence on pay-day of employés by whom earned, and the subsequent inability to find the men after repeated efforts. Authority for deposit and full explanation filed with account current for February, 1890.

(2) *Wreck in Great Wicomico River, Virginia.*—Notice was received on February 3, 1890, that the wreck of the canal-boat *W. M. B. Adamson* was sunk off the mouth of Cockle's Creek in Great Wicomico River, Virginia. It was a dangerous obstruction to navigation.

Proposals for removal of wreck were invited by advertisement of March 7, 1890, and, on recommendation to the Chief of Engineers a contract was made April 18, 1890, with the lowest bidder, Mr. Louis E. Broom. The vessel was entirely removed for the sum of $380.

After advertisement by posting handbills, under authority dated May 21, 1890, the wreck and contents, about 5 tons of coal, were sold at public auction, at Woodhull's wharf, on May 14, 1890, for $66. This sum was deposited in the Treasury, as required by section 4 of the river and harbor act of June 14, 1880.

Abstract of proposals for removal of wreck in Great Wicomico River, Virginia, opened at 12 m. April 7, 1890.

No.	Name and address of bidder.	Commenced.	Complete.	Price.
1	Louis E. Broom, 1123 Patapsco street, Baltimore, Md.	Ten days after approval of contract.	Within thirty days...	$380
2	W. H. French, Norfolk, Va.....	....do	....do	*750
3	Thomas P. Morgan, Washington, D. C.	....do	....do	1,800

*Remove wreck, etc., for $540 and possession of barge and contents.

L 5.

PRELIMINARY EXAMINATION OF CHICKAHOMINY CREEK [RIVER], VIRGINIA.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., December 19, 1888.

GENERAL: I have the honor to submit the following report of a preliminary examination of Chickahominy Creek, Virginia, which was authorized by the act of August 11, 1888, and was assigned to me by your order of September 29, 1888. The designation of "creek" used in the act of appropriation is a misnomer. The proper designation is "river."

The name Chickahominy Creek can not be found in the Gazetteer nor in the maps of Virginia. There can be little doubt that Chickahominy River was intended; the word "creek" was employed to designate the part of the river above the head of navigation. This part of the river was described in the Report of the Chief of Engineers for 1875, page 170, Part II. At that time its improvement was not deemed advisable, and recommendation was withheld until the bars had been removed in the lower part of the river between Windsor Shades and the mouth, a distance of about 27 miles. The improvement of this part of the river is now completed in accordance with the original project, and it seems proper, therefore, to consider the propriety of beginning the much-needed improvement above the "Shades."

DESCRIPTION.

Between Long Bridges and Forge Bridges (Providence Forge), a distance of about 10 miles, the river may be generally described as a cypress swamp of from one-half to 1 mile in width, intersected by a channel from 30 to 80 feet in width, which is crossed on the Mechanics-

ville road by a causeway and six bridges. This swamp is a tangle of bogs not favorably known to the Army during the late war.

It is not proposed to improve this part of the river.

From Providence Forge (Forge Bridges) to Windsor Shades, a distance of about 5 miles, may be regarded more favorably.

Windsor Shades Bar is at the head of the improvement begun by the Government in 1878.

Between the "Forge" and the "Shades" the old channel of the river is impassable, but rafts occasionally find a way by an old canal, cut in colonial times by the British Government, as a means of transporting the Virginia tobacco, upon which a heavy tax was levied. For the greater part of 5 miles the channel is tortuous, of 20 to 25 feet in width, flowing between low, swampy banks, which open into lagoons or bays of wide water. This insignificant part of the river connects the timberland above with the navigable water below. It should not be forgotten that between Windsor Shades and the mouth the river has a minimum depth of about 8 feet at low water, with 14 feet of water upon the bar at the mouth.

TRADE.

The trade, which consists principally of timber, has increased from $200,000 in 1878, when the improvement began, to about $600,000 at the present time. The trade would be largely increased by improving the river from Windsor Shades to or nearly as far as Providence Forge. A large supply of cypress, oak, and poplar timber can be found in the forests above the Forge, and it is chiefly as an outlet for this timber that the improvement is needed. The improvement should not be described as for Chickahominy Creek. It is a part of Chickahominy River, which has received occasional appropriation from Congress since June 13, 1878, amounting to $19,000 at the present date. The improvement of this part, between Windsor Shades and the mouth, has been completed according to the original projects, the trade has increased about threefold, and shippers now ask for an increased depth of the channel, and for an improvement of the upper part, between Windsor Shades and Forge bridges. This will require a revision of the original project for improving the river. For the above reasons I think the Chickahominy River between Providence Forge and Windsor Shades is worthy of improvement.

The least amount that will enable me to make the survey and report contemplated by the act, including the project and estimate of the cost of the improvement, is $200.

Very respectfully, your obedient servant,

S. T. ABERT,
United States Agent.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

SURVEY OF CHICKAHOMINY RIVER, VIRGINIA.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., November 30, 1889.

GENERAL: I have the honor to submit the report of a survey and estimates for the improvement of Chickahominy River, Virginia, from Providence Forge to Windsor Shades, made in obedience to your order of April 1, 1889.

SURVEY OF CHICKAHOMINY RIVER, VIRGINIA, ABOVE WINDSOR SHADES.

The survey begun on April 24 was completed on May 7, 1889, as thoroughly as the small sum allotted for this purpose would permit.

The survey began at Windsor Shades and closed at the outlet of the canal below Providence Forge. The distance covered, measured along the channel of the river, is about 25,500 feet, or 4.8 miles.

On account of the adjoining swamps, base lines were measured across the water at convenient intervals by stretching a measured wire, and a sextant was used for taking all of the angles.

Where practicable, trees at nor near the stations were marked with the numbers of the stations along the entire length of the survey.

BENCH-MARKS.

Bench-marks were placed at six points, which are marked upon the accompanying chart. A tide-gauge was placed at the Lower Holly Landing. One had been previously set at Windsor Shades. Both were suitably referenced.

TIDES.

The range of tides at Windsor Shades is about 3 feet. At this point freshets slightly influence the stage of water, which is more affected by wind.

The highest stage of water in recent years occurred in April, 1889, when it reached a point 6.8 feet above mean low water.

A freshet prevailed in the river during most of the time of the survey, and the mean range of the rise and fall near Providence Forge could not be determined. It is said to be about 2 feet.

DESCRIPTION OF THE RIVER.

Above Windsor Shades the Chickahominy River drains the heavily-timbered swamps above and around it. Near Windsor Shades it begins to assume the character of a tidal stream.

Its average width near Windsor Shades is about 300 feet, with a depth at low water in the channel of from 7 to 13 feet. The width and depth rapidly diminish as the stream is ascended. At Winn's Landing, about 2 miles above Windsor Shades, the width of the stream is about 150 feet and the depth in the channel about 6 feet; and at Holly Landing, just below the outlet of the canal and $4\frac{3}{4}$ miles above Windsor Shades, the width is about 80 feet and the depth is about 3 feet at low water. From Roper's Neck, $2\frac{1}{4}$ miles above Windsor Shades, to Providence Forge, the average channel depth is probably less than 4 feet.

The stream is tortuous and the narrow portions are difficult of navigation.

At the freshet stage very little sediment is ever carried in the water; consequently channels once dredged do not quickly fill.

NAVIGATION.

This part of the stream is navigated by lighters, which carry wood and railroad ties from the different landings to schooners lying at or below Windsor Shades. These lighters are from 16 to 20 feet wide, from 40 to 60 feet long, draw $3\frac{1}{2}$ or 4 feet of water when loaded, and

carry from 25 to 30 cords of wood each. There are probably six or eight so engaged, but none of them continuously. Most of the wood and ties shipped from the part of the river immediately below Windsor Shades is brought from the landings above upon these lighters, which pass over the shoals at stages of water from high water to half tide.

The trade would be largely increased by improving the river from Windsor Shades to or nearly as far as Providence Forge. A large supply of cypress, oak, and poplar timber can be found in the forests above the Forge, and it is chiefly as an outlet for this timber that the improvement is needed.

The principal wood-landings above Windsor Shades are Holly Landing, near Providence Forge; Pierce's Landing, one-half mile below Holly Landing; Old House Landing, $1\frac{1}{8}$ miles below; and Winn's or Page's landing, $2\frac{1}{2}$ miles below Holly landing and 2 miles above Windsor Shades.

OBSTRUCTIONS.

Vessels drawing 5 feet of water encounter the following obstructions:

(1) *Bars (enumerated in ascending order from Windsor Shades)*

	Stations.	Approximate length.
		Feet.
Mill Creek Bar, from station	8 to 9	350
Bar at Rock Hole Thoroughfare	17 to 25	650
Rock Hole Bar, from station	28 to 31	800
Winn's Bar, station	34 to 43	2,200
Bar between stations	61 to 68	500
Do	78 to 94	1,800
Do	96 to 109	2,800
Bars between stations	109 to 161	5,200
Total length	----------	14,300

DEPTH.

The depth of cutting required to make a channel from 5 to 6 feet deep would vary from 1 to 5 feet, being most on the upper bars.

MATERIAL.

The material in the bars becomes harder as the river is ascended. It is mud and sand at Mill Creek Bar; sand and clay at Winn's Bar; and sand, clay, and gravel from there to Providence Forge.

BORINGS.

Borings taken at frequent intervals showed easy penetration to the required depth, except near the mouth of the canal, where hard clay was found, difficult of penetration.

(2) *Snags and similar obstructions.*—Snags, sunken logs, and fallen and overhanging trees to the number of about 50 were counted in and near the channel. Probably many more would be found by a sweep-line. About six large live cypress knees, or stumps, with the points from 2 to 5 feet below the surface at low water, would require removal. These obstructions will be difficult of removal, as the roots cover a considerable area.

Some of the trees in the upper part of the river are very large, and reach almost across the stream.

(3) *Wrecks.*—There are two wrecks, situated at stations 43 and 91. The former is that of a schooner-rigged scow, and the latter is an ordinary lighter-scow, about 18 feet by 50 feet on deck. Both are in the channel.

DUMPING.

The numerous creeks and thoroughfares will probably afford sufficient room for dumping all of the material to be dredged.

IMPROVEMENT.

On account of the large proportion which the cost of excavating a channel would bear to the annual amount of trade it is believed that a dredged channel for the entire distance is not advisable. Safe navigation for sailing vessels or steam-boats of even small size can be made above Roper's Neck only at extraordinary cost; and the excavation of one or more turning basins would be necessary. The cost of such excavation can not be determined with the present funds. A fair channel can be made from Windsor Shades to Roper's Neck, 2¼ miles above, at a moderate cost, by excavating through the bars and removing the obstructions between these points; and an estimate can be made without additional expense during the operation of removing snags and trees which now obstruct navigation.

For these reasons, I would respectfully recommend that the improvement be limited for the present to the removal of snags, trees, stumps, wrecks, and such obstructions. These will accumulate from year to year, but it is estimated that the sum of $4,000, if made in one appropriation, will be sufficient for removing all that now interfere with or endanger navigation. The field maps of this survey, in two sheets, on a scale of $\frac{1}{2000}$, with the records of the survey, are on file in this office.

The following charts accompany this report, viz:

(1) A chart* of the Chickahominy River, from Providence Forge to Windsor Shades, on a scale of $\frac{1}{20000}$.

(2) A chart† of the Chickahominy River, from Providence Forge to the mouth, on a scale of $\frac{1}{60000}$, showing the portion of the river surveyed, inclosed by a heavy dotted line.

Very respectfully, your obedient servant,

S. T. ABERT,
United States Agent.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

L 16.

PRELIMINARY EXAMINATION OF OCCOQUAN CREEK, VIRGINIA.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., December 4, 1888.

GENERAL: I have the honor to submit the following report of a preliminary examination of Occoquan Creek, Virginia, provided for in the act of appropriation of August 11, and assigned to me by your letter of September 29, 1888.

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* Omitted; printed in House Ex. Doc. No. 41, Fifty-first Congress, first session.
† Omitted.

PAST HISTORY.

An examination and survey of the river was directed by the river and harbor act of June 10, 1872, and the report will be found in the Report of the Chief of Engineers for 1873, pages 819 and 825. Between 1873 and 1878 four appropriations were made, amounting to $25,000. This money was expended in the following work:

(1) In dredging through a small bar opposite the town of Occoquan.

(2) In constructing a dike and in dredging through a bar about one-half mile below the town.

(3) In dredging a channel through the "Upper Mud" about one-half mile below the railroad bridge.

(4) In dredging a channel through the "Lower Mud" near the mouth of Occoquan Bay.

These channels were dredged to a depth of about 6 feet at low water.

For ten years since the completion of the work the citizens of Occoquan and the farmers of Fairfax County on the north side of the river, and of Prince William County on the south side, have made no complaint. They now come forward with a request for an improvement with greater depth than that formerly executed, and upon a scale suitable to the present and prospective wants of trade.

EXAMINATION.

My examination shows that the bar opposite Occoquan has refilled, and will require regulating work; that the bar about one-half mile below the town requires further diking and dredging; that the cut which is about one-half mile below the railroad bridge, at the "Upper Mud," requires widening and deepening, although it has preserved its depth; and, lastly, the cut at the "Lower Mud" requires widening and deepening, having filled from causes mentioned in the Report of the Chief of Engineers for 1876, page 347.

It would be advisable to consider a new location of the channel through the "Lower Mud," which might harmonize with the cross currents and the movement of the ice.

The length of the creek is about $5\frac{3}{4}$ miles, and the probable length of the proposed improvements will be about 3,000 feet.

STATISTICS.

A careful statement of receipts and shipments prepared by Mr. J. Janney, the owner of the valuable mills in Occoquan, shows the trade for 1887 as amounting to $176,000.

Two hundred and forty-two thousand barrels of flour are shipped annually. Shipments from below the railroad bridge are not known.

RECOMMENDATION.

It is believed that the trade would be increased by an improvement in the navigation, which is now obstructed by filling in the former channel. For the reasons, which are the same, and which induced Congress to appropriate $25,000, between 1873 and 1878, for the improvement of Occoquan Creek, I would again recommend it as worthy of improvement. The least amount that w'll enable me to make the survey and

report contemplated by the act, including a project, with estimate of the cost of the improvement, is $450.

Very respectfully, your obedient servant,

S. T. ABERT,
United States Agent.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

SURVEY OF OCCOQUAN CREEK, VIRGINIA.

UNITED STATES ENGINEER OFFICE,
Washington D. C., December 13, 1889.

GENERAL: I have the honor to submit the report in duplicate of a survey for the improvement of Occoquan Creek, Virginia, from the town of Occoquan to its mouth in the Potomac River, made in obedience to your order of April 1, 1889.

The field work was begun on August 24, and was finished on September 3, 1889. The survey covered the distance from the town of Occoquan to the 9-foot curve in the Potomac River, which is about 6 miles. Soundings were taken and located over the entire distance, except where the depth at low water was more than 9 feet. The length of channel sounded was about 5 miles. For want of funds the least important part of the channel surveyed, from a short distance beyond Sandy Point to the 9-foot curve in the Potomac River, has not been platted.

BASE-LINES, PERMANENT STATIONS, AND GAUGE-MARKS.

Separate base-lines, aggregating 3,761.67 feet in length, were carefully measured for different parts of the work.

STATIONS.

Fifteen primary stations were set for triangulatiou. These were cedar hubs, carefully set in the ground and suitably marked with tacks.

GAUGE-MARKS.

Five gauge-marks were placed as follows:

At Sandy Point, three galvanized nails were driven at 3 feet above low water in a cedar pile below the point.

At the clump of piles marking the eastern side of the channel, and next above Sandy Point, a row of galvanized nails was driven in an oak pile at 2 feet above low water.

At the southeast corner of the stone pier, at the northern end of the Baltimore and Potomac Railroad Bridge, a horizontal mark was cut in the stone at 3 feet above low water.

At the angle in the dike about one-half mile below Occoquan, a row of galvanized nails was driven in the dike at 3 feet above low water.

At the southeast corner of Clark's Wharf, at Occoquan, a row of galvanized nails was driven in the wharf at a point which is 3 feet above low water.

RANGE OF TIDE.

The mean range of the rise and fall of tides upon the creek is about 1.8 feet, as determined during the survey.

CROSS-SECTION.

The cross-sectional area of the stream was determined on a line about 2,000 feet below the Baltimore and Potomac Railroad Bridge. Along this line the depth of the channel is from 10 to 12 feet for a width of 220 feet.

The determinations are as follows:

	Approximate area.	Approximate width.
	Sq. feet.	*Feet.*
At low water	3,587	540
At high water	4,667	600

BORINGS.

Sixteen borings were taken at the different bars in the channel and near the lines for constructing dikes.

Their positions are shown upon the charts.

The penetrations attained ranged from 10.7 feet to 15.3 feet below low-water level, without stoppage, except in one case. (See notes and field maps.)

DESCRIPTION.

Occoquan Creek has been described in the reports of a former survey (see Report of Chief of Engineers for 1873, pages 819 and 825), therefore only a brief description is required here. It is a tributary of the Potomac River, into which it empties about 26 miles below Washington.

The head of navigation is at the village of Occoquan at about 6 miles above the entrance of Occoquan Bay, which is situated at the mouth of the creek.

The obstructions in the way of vessels drawing six feet of water are as follows:

(1) A short sand-bar opposite Occoquan, upon which the depth is now about 4 feet at low water.

(2) A sand-bar one-half mile below Occoquan, having a least depth of about 4.2 feet at low water.

(3) A bar known as the "Upper Mud," about $2\frac{1}{4}$ miles below Occoquan, through which is a dredged channel from 5 to 6 feet deep at low water, but only about 50 feet wide.

(4) A bar known as the "Lower Mud," about $3\frac{1}{2}$ miles below Occoquan, upon which the depth is from 3 to $3\frac{1}{2}$ feet at low water.

(5) The mud flat in Occoquan Bay, extending from Sandy Point to the 9-foot curve in the Potomac River, over which the depth is about 5 feet at low water. This flat is nearly 2 miles across.

From Wagner's Point about 1 mile below Occoquan, to the Upper Mud Bar, a distance of $1\frac{1}{4}$ miles, the natural channel is deep and wide.

The upper two bars are formed by sand brought down by freshets. Upper Mud Bar is formed by mud and sand deposited at the sudden ex-

pansion of the creek into the wide and shallow Belmont Bay. At Lower Mud Bar, the effect of great width is aided by conflicting currents in the tidal flow from the creek and that from Belmont Bay; the directions of these currents at certain stages of tide being about at a right angle to each other, viz, one from the north, the other from the east at ebb tide, which are reversed at flood.

PREVIOUS IMPROVEMENT AND PRESENT CONDITION.

Between 1873 and 1879 channels were dredged through the four bars first mentioned to a depth of 5 feet below low water, and in 1879 a sheet-pile dike was built at the bar one-half mile below Occoquan. The dike has been slightly damaged, probably by ice, and will require some repair.

The channel dredged opposite Occoquan has filled to a depth of about 4 feet. The channel at the bar next below has filled slightly at the upper end, so that the least depth is now 4.2 feet, but at the lower part it maintains a depth of fully 5 feet. The channel at the Upper Mud has maintained its original dimensions, and the depth has somewhat increased. This is on account of the deposit of a bank of dredged material along the cut.

The channel at the Lower Mud Bar has, for reasons stated above, filled to a depth of about 3 feet, or nearly to the original depth.

It appears that in order to maintain the dredged channels contracting works will be required at the points where filling has occurred; and if increased depth and width are required, such works will be needed along the entire channel excavated.

NAVIGATION AND TRADE.

The trade consists principally of shipments of wood, lumber, railroad-ties, and flour, all of which are shipped by water. The total vaule of shipments and receipts per annum is stated by trustworthy representative citizens to be about $225,000. There are now constantly engaged in trade one steam-vessel, four sail-vessels, and eight barges. The steam and sail vessels ply mostly to Washington and Alexandria. They are loaded to a draught of only 4½ feet, which is the greatest draught that can now be safely carried into the creek at high tide. The barges ply to Baltimore and Philadelphia, and are of deeper draught. These are loaded by lighters at deep water in the Potomec River, their cargoes being transferred from Occoquan for the intervening distance of about 6 miles.

Messrs. L. Ledman and T. Janney, shippers at Occoquan, make the following statement:

> This country abounds in timber, viz, railroad-ties, cord-wood, poplar wood, hoop-poles, hogshead-hoops, etc.

The fall of the creek above Occoquan affords a good water-power, which is partly utilized by a flouring-mill of a capacity of 75 barrels daily.

FUTURE IMPROVEMENT.

The citizens of Occoquan desire a permanent channel through all of the bars, with a depth of not less than 6 feet at low water, and of sufficient width to be easily navigable. In order to preserve the channel to this depth, it will be necessary to dredge the cut to a depth of not less than 8 feet at low water. The channels through the bars should be made

100 feet wide, except at Low Mud Bar, where the width should be made 150 feet, on account of a greater tendency to fill from the sides and because of the greater width of the stream at this bar. The estimate submitted below does not provide for a channel through the long flat in Occoquan Bay, extending from Sandy Point to deep water in the Potomac River. It is believed that the cost of making and maintaining a channel through this bar would be beyond a reasonable proportion to the trade of the creek. The depth upon this bar remains practically constant at from 5 to 6 feet below low water, and will probably always govern the navigation of the creek and the class of vessels entering it.

Contracting works and works for the protection of the channels excavated between Occoquan and Sandy Point must be provided, in order to maintain the depth made by dredging through the bar. At the bars at Occoquan and just below these may be built of piles and brush. At Upper and Lower Mud Bars, where the conditions differ from those above, it will be less expensive and probably as effective to deposit a portion of the dredged material along the cuts at a sufficient distance to prevent its return, and to re-enforce and protect the mud-banks thus formed at all exposed points by wings built of brush and piles. At Lower Mud Bar, where the channel previously dredged has been filled by the effect of tidal currents flowing directly across it to and from Belmont Bay on the east, a core or nucleus for the proposed mud-bank should be constructed, to prevent erosion of the bank by ice, waves, or currents. This nucleus may be built of piles and brush. The bank thus constructed will separate the two currents coming from Occoquan Creek and from Belmont Bay at the point where they now meet, and will divert them into parallel courses at the point of union.

The tidal currents from and into Belmont Bay which encounter the currents from and into the main channel of the Occoquan will always tend to form a bar in the neutral axis of these currents near Sandy Point.

This conflict can only be prevented by the construction of a dike which will largely increase the cost of the estimate submitted below, and as several conditions of the problem are at present unknown it is proposed to omit the consideration of such works until further observation shall demonstrate their necessity. An estimate for this object is therefore omitted.

The outlines of the channels recommended and the locations and measurements of the contracting works which seem best adapted to the purpose are shown on sheets 1 and 2 of the drawings accompanying this report.

The dikes for the upper bars may be somewhat more costly than the similar constructions at the lower bars. They should be capable of retaining sand placed to low-water level behind them. At a part of these dikes, at the shore ends, crib-dikes may be found necessary on account of a possible lack of sufficient penetration for the piles.

DUMPING-GROUNDS.

A part of the sand excavated at the upper bars can be placed behind the dikes at those bars. At Upper Mud Bar about 17,000 cubic yards of material can be deposited in the mud banks as planned along the channel. At Lower Mud Bar about 54,000 cubic yards can be deposited in mud banks along the channel. The remaining material must be deposited at distances varying from 2 to 5 miles from the points of excavation. A suitable dumping-ground, which will hold a large part of this

material, exists in the cove on the eastern shore of Occoquan Bay, between Sandy Point and High Point. This ground was examined, but the notes have not been platted. (See field book and sounding book of this survey.) A part of the material may require to be deposited along the shores of the Potomac River, just outside of the mouth of the creek.

Special examination should be made of the localities proposed to be used as dumping-grounds before the preparation of specifications for contract work.

ESTIMATE.

The estimate for the improvement, based on the drawings transmitted herewith, is as follows, viz:

Dredging calculated to a depth of 8½ feet.

Occoquan Bar:		
900 linear feet of brush and pile matress dike, at $4 per linear foot	$3,600.00	
14,133 cubic yards of sand excavation, at 25 cent per cubic yard	3,533.25	
		$7,133.25
Bar one-half mile below Occoquan:		
2,000 linear feet of brush and pile mattress dike, at $4 per linear foot	8,000.00	
27,371 cubic yards of sand excavation, at 25 cents per cubic yard	6,842.75	
Repairing 50 linear feet of the present dike, at $3 per linear foot	150.00	
		14,992.75
Upper Mud Bar:		
750 linear feet of brush and pile mattress dike, at $3 per foot	2,250.00	
71,000 cubic yards of mud and sand excavation (to be partly deposited at a distance of 80 feet from the edge of the cut), at 20 cents per cubic yard	14,200.00	
		16,450.00
Lower Mud Bar:		
800 linear feet of brush and pile mattress dike, at $3 per foot	2,400.00	
3,000 linear feet of brush and pile dike (nucleus), at $2.50 per foot	7,500.00	
137,828 cubic yards of mud excavation (partly deposited along the cuts), at 20 cents per cubic yard	27,565.60	
		37,465.60
Total		76,041.60
The above figures are estimated to be contract prices, but these will depend somewhat upon the amounts of appropriations. To this must be added 20 per cent. for the cost of inspection, superintendence, and other contingencies		15,208.32
Total amount of estimate		91,249.92

The original field maps, in two sheets, with the records of the survey, are in this office.

CHARTS.

The following charts * accompany this report, viz:

(1) Sheet 1, scale $\frac{1}{2000}$, showing the bars at Occoquan and a half mile below, with the proposed improvement.

(2) Sheet 2, scale 400 feet to 1 inch, showing the bars at Upper Mud and at Lower Mud, with the proposed improvement.

(3) An index map, scale $\frac{1}{4000}$.

* Omitted; printed in House Ex. Doc. No. 75, Fifty-first Congress, first session.

The survey was made and the field sheets were skillfully prepared by Mr. L. R. Grabill, assistant engineer.

Very respectfully, your obedient servant,

S. T. ABERT,
United States Agent.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

L 17.

PRELIMINARY EXAMINATION OF AQUIA CREEK, VIRGINIA.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., December 3, 1888.

GENERAL: In compliance with your order of September 29, 1888, I have the honor to submit a report upon the result of a preliminary examination of Aquia Creek, Virginia.

DESCRIPTION.

From Wharton's Landing to the Narrows the course of the creek winds through marshes with a depth of from 3½ to 17 feet at low water; from the Narrows to the mouth the depth varies from 4 to 6 feet; below the Narrows the creek expands to three quarters of a mile wide and then gradually widens to about 3½ miles at the mouth. From the Narrows to the mouth the distance is about 4½ miles. Before the improvement (in 1878) the least depth in the channel was about 2 feet at low water. It is now about 4 feet.

PAST HISTORY OF THE IMPROVEMENT.

Report of a survey of the creek, made under the order of Col. William P. Craighill, will be found in the Report of the Chief of Engineers for 1872, page 708.

Between 1872 and 1878, $10,000, appropriated by Congress, were expended in cutting a channel near Austen's Creek and Wharton's Landing, and from a point below the Narrows nearly as far as the railroad bridge, a distance of 4,750 feet, and for a distance of about 1,800 feet below the bridge. Three cuts were made with a width of about 50 feet and a low-water depth of from 4 to 5 feet. The total length of the cuts was 2⅓ miles, and the least bid for the dredging was 11¾ cents.

The depth in the improved channel has but slightly changed since the close of work, about ten years since, but shippers find the depth insufficient for the present demand upon the navigable condition of the creek.

A petition, signed by shippers and farmers of Stafford County, has been received respectfully requesting an improvement of the creek to meet the present demands of trade.

STATISTICS OF TRADE.

From letters before me I am able to gather the wishes of those interested in regard to the depth of the channel desired, and also to estimate the present trade of the creek.

Mr. Flatford estimates the value of shipments at about $75,000 and the receipts at $15,000, or the total shipments and receipts above the railroad bridge at about $90,000 annually.

The largest items in the statistics are found in railroad ties, pine and oak wood, poplar and cedar, and in lumber. Poplar is shipped to Philadelphia, where it is converted into pulp for paper manufactures; but the large barges with the material are delayed by the necessity of completing their loads below the bridge.

The Aquia Creek quarries have been known and worked for many years. They afford an inexhaustible supply of stone, which can be economically worked, and the stone has been used in building parts of the Capitol and Treasury Department, at Washington, D. C.

The present cost of shipping seems to be the chief objection to its extensive introduction into the markets of the country.

Shippers desire a channel of not less than 8 feet in depth at low water and of a width at bottom of 100 feet.

This desire seems to me to be reasonable, and I respectfully recommend the creek as worthy of improvement.

The least amount which will enable me to make the survey and report contemplated by the act including a project with estimate of the cost of the improvement is $350.

Very respectfully, your obedient servant,

S. T. ABERT,
United States Agent.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

SURVEY OF AQUIA CREEK, VIRGINIA.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., January 13, 1890.

GENERAL: I have the honor to submit the report in duplicate of a survey for the improvement of Aquia Creek, Virginia, made in obedience to your order of April 1, 1889.

Description.—The creek has been described in the report of Capt. C. B. Phillips upon a survey made by him under the direction of Major Craighill in 1871. (See Report of Chief of Engineers for 1872, page 708.)

Aquia Creek lies wholly in Stafford County, Va., and is a tributary of the Potomac River, into which it empties about 41 miles below Washington. The head of navigation is at Wharton's Landing, about $7\frac{1}{4}$ miles from the mouth of the creek. The channel near this point is very shallow and narrow. Dent's Landing, about three-quarters of a mile below Wharton's Landing, is as high as navigation can be carried with safety. It is not practicable, except at great expense, out of proportion to the trade, to maintain a channel farther up-stream, and improvement above Dent's Landing is not recommended.

The only obstructions from Dent's Landing to the "Narrows," 2 miles farther down, consist of the following:

(1) A short bar, about 350 feet in length, at the mouth of Austen's Creek, where the channel is very narrow and the depth at low water is not more than 4 feet.

(2) A wreck of a vessel about 100 feet long at Coal Landing, which occupies a portion of the channel. This was sunk about 1881. It has

a depth of about 2 feet at low water upon the highest portion. (See sounding-book, this survey, last page.)

(3) One large snag, in the channel, but visible, about four-tenths mile below coal landing.

With these exceptions, the depths at low water from Dent's Landing to Coal Landing are from 5 to 15 feet; and from Coal Landing to the "Narrows" are from 8 feet to 16 feet. No improvement is required in this distance but the removal of the obstructions named.

At the "Narrows," $2\frac{3}{4}$ miles below Wharton's Landing, the stream suddenly widens, the width below varying between the "Narrows" and the mouth from 1,000 feet to 1 mile. From this point nearly to the mouth for a distance of 19,000 feet, or somewhat more than $3\frac{1}{2}$ miles, there was originally a continuous shoal, on which the depth at low water varied from 2 feet at the upper end to 6 feet at the lower end The bottom is principally soft mud. It is this shoal which forms the principal obstruction to the navigation of the creek.

Through the upper end of this flat, from the "Narrows" to a point about 1,800 feet below the Richmond, Fredericksburg and Potomac Railroad Bridge, a distance of about 8,500 feet, a channel from 40 to 50 feet wide and about 5 feet deep at low water was dredged between 1874 and 1878.

It was carried to the original natural channel, having a depth of about 5 feet at low water, below the railroad bridge. Vessels pass through the railroad bridge by means of a draw, which is only 28 feet in width. This draw was improperly located to suit the convenience of the railroad rather than navigation, and at present it seems best to accept its position and to make the new cut pass under the bridge at this point. The channel formerly dredged is still about 40 feet wide and from 4 to 5 feet deep, the dimensions having been but little changed by filling. In some places the depth has increased since dredging. Its width and depth are, however, insufficient for good navigation.

The parts of this shoal which now offer the greatest obstruction are those off and below Davis's Point and Watson's Point, where no channel has been excavated. At these places the depths are from 4 to $4\frac{1}{2}$ feet at low water. Vessels can not be loaded in the creek to deeper draught than this, as the range of tide is very small—about 1.4.

From the lower end of this shoal at Thorny Point to deep water in the Potomac River, the channel is more than 7 feet deep, except at one short bar just below Simms's Point, where the depth is from 5 to 7 feet for a distance of about 600 feet.

Survey.—The field work of the survey was begun on September 3, 1889, and was closed on September 16, 1889. On account of the small amount of funds available the observations were necessarily limited in their extent to such only as were most needed for the purposes of an estimate.

The survey covered the distance from Wharton's Landing to the 9-foot curve in the Potomac River, which is about 8.1 miles.

Base-line, shore stations, etc.—A base-line 2,558.8 feet long was measured near Thorny Point. Upon this was based a system of triangles by which fourteen shore-stations were located at the prominent points from the mouth of the creek to the "Narrows."

From these stations the sounding ranges were located by triangulation. At the railroad bridge the work was checked by a base-line 1,110.95 feet in length, measured on the bridge. The observations, on

being platted, were found to agree very closely with those of the former survey.

The hubs placed at the stations were of locust, carefully set in the ground and suitably marked with tacks. They will be useful in connection with any future operations.

The important channel ranges were referenced by marks placed on the shore and on the bridge. (See chart and field-notes.)

Soundings.—From Wharton's Landing to Coal Landing, a distance of 1½ miles, lines from 100 to 200 feet apart, perpendicular to the channel, were located by measurement for about 3,300 feet at the bars, and soundings were taken along these lines, across the channel, at intervals of 10 feet. From Coal Landing to the "Narrows" no examination was required, the depth being already sufficient.

For the entire distance of 5.4 miles, from the "Narrows" to the 9-foot curve in the Potomac River lines perpendicular to the channel, from 200 to 800 feet long and about 400 feet apart, were carefully sounded.

The entire distance over which soundings were located by measurement or triangulation was about 6 miles. But few soundings were taken except those in and near the proper course for a channel. The shoreline of the survey made by Captain Phillips in 1871, and the soundings of that survey, except in and near the channel, have been used in the drawing.

Borings.—Nineteen borings were taken at points along the channel. Their positions are shown upon the chart herewith. The bottom at and near Wharton's Landing was found to be sand on top, then clay and gravel. From the "Narrows" to Simms' Point, including nearly the whole length of the proposed dredging, it is very soft mud, except at one point above the railroad bridge known as the "gravel pile," where it consists of sand and gravel with small stones, of the character of soft sand-stone. The extent of this hard material is limited to a distance of about 200 or 300 feet along the channel.

From Simms' Point outward to the 9-foot curve the material is mostly sand. No difficulty was experienced in reaching a depth of from 11 to 17 feet below low-water level, except at the "gravel pile," where the penetration was difficult, but still practicable.

For much the greater part of the proposed channel, the softness of the bottom is such as will make it necessary to dredge a wide cut to allow for long slopes of the sides, which will assume a slope of probably not more than 1 foot in 10, or possibly still flatter. (See chart and sounding-book for borings.)

Range of tide.—On account of storms the tides were too irregular during the short stay of the party to properly determine the range. The mean range observed was 1.1 feet at Thorny Point. The range at Liverpool Point, on the Potomac River, 6 miles above the mouth of the creek, is stated on the Coast Survey charts to be approximately 1.4 feet. This is probably more nearly correct.

Gauge references.—The low-water level, as determined by observations and other information received during the survey, was referenced at four points, as follows, viz:

(1) At Wharton's Landing three galvanized nails were placed $6\frac{1}{10}$ feet above low-water level, in a leaning sycamore at the water's edge.

(2) At the northeast end of the draw-bridge, on the lower leg of the *third bent* of the trestle from the shore, a row of nails was placed at 2 feet above low water.

(3) Between the landing at the "Richmond Ducking Club" house and the landing at Thorny Point, on a pile about 50 feet from high-

water mark, a row of nails was placed at 3 feet above low water, and 2 nails were placed at 2 feet above low water.

(4) On the third pile outward from station D, at the inner end of the old railroad wharf, a row of nails was placed 3 feet above low-water mark.

Cross-section.—A rough cross-section of the creek, taken near Thorny Point, upon a line on which the depth in the channel is not less than 10 feet for a width of 150 feet, shows the following result:

	Approximate width.	Approximate area of cross-section.
	Feet.	*Square feet.*
At low water	3,400	13,940
At high water	3,500	18,770

RESOURCES OF TRIBUTARY COUNTRY.

The creek passes through a fertile farming country, a part of which is dependent upon the navigation for supplies. Large quantities of pine, oak, and poplar timber are found near the upper part. The pine and oak timber furnish sawed lumber and firewood, which are shipped to Washington; and railroad ties, sent principally to Philadelphia. The poplar wood is shipped to Philadelphia and is used for the manufacture of paper. Five or six saw-mills are said to be engaged in sawing lumber, a part of which is shipped. There are several fisheries on the creek.

The quarries of sandstone existing at several points above the railroad bridge are well known. The stone is a whitish-gray in color, is easily worked, and some of it is of excellent quality for building. The durability of the best grade has been well tested. As with most quarries, there are several grades. The quantities are said to be almost inexhaustible. The quarries are conveniently situated for water transportation of their product. Stone from these quarries was largely used in the construction of some of the earlier public buildings in Washington, notably in the Capitol, in the Treasury, and in the White House. Recently but little of the stone has been shipped, which is probably largely due to the ease with which other stone is procured, and the difficulty and cost of transportation arising from the lack of a suitable channel in the creek.

Navigation and trade.—The principal shipments are those of cordwood, poplar wood, and railroad ties. The former is shipped in light-draught sail-vessels, schooner-rigged, known as "long-boats." The poplar wood and ties are shipped in barges which must be of greater draught, to enable them to safely ply Chesapeake Bay and Delaware Bay to Baltimore and Philadelphia. The barges have a draught of 8 feet when loaded. They load down to 4½ feet deep at the landings, pass over the bars at high water, and complete their loads from lighters or long-boats at deep water, at the mouth of the creek.

A considerable amount of lumber, piles, cedar posts, spokes, produce, and grain is shipped. Fish and garden truck are shipped at certain seaons.

The larger part of the shipments by water is from Coal Landing. The remainder is mostly from landings above that point.

The annual value of shipments by water is stated by Mr. R. L.

Flatford, of Garrisonville, Va., who is largely interested in the trade, to be approximately $74,500, and the annual receipts of merchandise, etc., by water are placed by him at approximately $15,000, making a total annual value of trade by water of about $89,500.

Mr. Flatford says:

> I believe if we could have our creek dredged so that a vessel or barge drawing 8 feet of water could come and go without hindrance that our trade would be increased at least 20 per cent.

Maj. E. T. D. Myers, of Richmond, Va., general superintendent of the Richmond, Fredericksburg and Potomac Railroad, states that the average number of vessels passing the draw of the railroad bridge in the summer months is 28 per month.

The trade would probably be considerably increased by shipments of stone if a channel were made suitable for the vessels required for its transportation.

Future improvement.—A channel for the navigation of the creek from its mouth to the "Narrows," should have a depth at low water of from 7 to 8 feet and a bottom width of from 90 to 100 feet. This will permit the egress at most stages of tide of loaded barges drawing 8 feet of water, and the necessity of lightering part of the loads a distance of 5 or 6 miles will be avoided. It will permit the entrance at all stages of such steamers as now ply the Potomac River and its tributaries. The depth proposed is the controlling depth at the entrance of the channel from the lower limit of the survey to Thorny Point. The proposed width, 100 feet at bottom, is necessary to enable vessels to pass each other safely in the long cut.

On account of the soft character of the material, and the consequent long slope which the sides of the cut will assume, it will be necessary to make the excavation 150 feet wide in order to secure and maintain the bottom width proposed (100 feet). This would probably be as economical and as safe as to build structures to maintain the width, while the beating of sailing vessels of light draught, or at high water, outside of and across the channel would not be interfered with by longitudinal dikes.

It is assumed from the present fair condition of the cuts which were dredged below the "Narrows" from ten to fifteen years ago that there will be no necessity for structures to maintain the dredged channel below the "Narrows," provided the excavated material be deposited upon lines nearly parallel to the channel and on both sides of it, so as to confine the greater part of the strength of the tidal current between the lines of deposit.

Below the railroad bridge the deposit should be made in three portions on each side of the channel; the upper deposit should leave a channel of about 1,100 to 1,200 feet wide at its upper end; the middle portion of the deposit should be at about 600 feet from the outer edge of the channel upon each side, and the lower or third portion should diverge so as to leave a channel-way of about 1,500 feet wide at the lower end. This width would permit the beating of vessels drawing about 5 feet of water. Above the bridge, where beating is not practicable on account of the shoal on each side, the deposits may be placed at distances of not less than 100 feet from the edges of the cut. Sufficient openings should be left at suitable points to permit the tidal flow into and out of the large bays on each side, and to allow the necessary ingress and egress of fishing-boats.

The deposits should be placed to the height of low water or half-tide,

if practicable, and may be 100 to 300 feet wide at base. Even in depths of 3 or 4 feet at low water, and in less, they will probably become covered with a kind of water-grass, which in the late summer grows over the shallow portion of the creek. This will protect the deposits from erosion and will render them less likely to spread. In the summer and fall it will force more of the current through the channel. Along the crest of the bank the willows should be encouraged to grow and any sort of suitable shrubbery should be planted.

A comparison of the charts so far as it could be made shows that apparently no large amount of deposit of silt has occurred since the survey made by Captain Phillips in 1871.

Through the short bar at the mouth of Austen's Creek, above Coal Landing, a cut 80 feet in width will be sufficient. The protection of the channel there would require about 100 feet of dike built of piles and brush, to deflect the current of Austen's Creek at its entrance into Aquia, so that its course may be more oblique to the main channel. If such an improvement as is suggested herein be made, the railroad company should be required to provide a draw with a width of from 36 to 40 feet in place of the one now in use. The present draw is only 28 feet wide, which is barely sufficient to admit some of the larger vessels now passing it.

The lines of the proposed cut and of the proposed deposits of dredged material are indicated on the chart herewith. The hatched portions show the required dredging, which is in three parts, viz:

At Austen's Creek for a length of about 350 feet (80 feet wide).

From the "Narrows" to Thorny Point, a distance of 19,000 feet (150 feet wide).

Below Simms' Point for a length of about 600 feet (150 feet wide).

ESTIMATE.

The estimate for the improvement, based upon the chart herewith transmitted, is as follows, the items being named in the order of importance, viz:

Excavation from Brent's Point to the "Narrows," for a cut 150 feet wide and 8 feet deep at low water, 434,390 cubic yards of soft mud, at 20 cents	$86,878
Excavation at the mouth of Austen's Creek, for a cut 80 feet wide and 8 feet deep at low water, 3,760 cubic yards of sand and mud, at 25 cents	940
For building 100 linear feet of brush and pile dike at the mouth of Austen's Creek, at $2.50 per linear foot	250
	88,068
The above are estimated to be the contract prices. To this must be added for superintendence, inspection, and other contingencies, 15 per cent., which amounts to	13,210
Making the total cost	101,278

To be completed for the above amount in not less than three years the appropriations should be about $33,800 for each year.

A cut 100 feet wide and from 6 to 7 feet deep at low water could be made for about one-half of the above estimate, but it would more rapidly decrease in width on account of the nature of the bottom.

As stated the decrease in the depth of the work already done has been found to be small after a lapse of from 10 to 15 years.

The cost of removing the wreck at Coal Landing is not included, as this may be done from the indefinite appropriation for removing sunken vessels.

The following drawings accompany this report:

(1) A field map,* scale $\frac{1}{10000}$, which is submitted in an incomplete condition on account of want of funds to finish it.

(2) A general map† (scale $\frac{1}{60000}$). The field books and other records of the survey are in this office.

The survey was skillfully made, with limited means at my command, by the party under Mr. L. R. Grabill, assistant engineer.

Very respectfully, your obedient servant,

S. T. ABERT,
United States Agent.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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* Omitted.

† Omitted; printed in House Ex. Doc. No. 135, Fifty-first Congress, first session.

APPENDIX M.

IMPROVEMENT OF CERTAIN RIVERS AND HARBORS OF NORTH CAROLINA AND SOUTH CAROLINA.

REPORT OF CAPTAIN WILLIAM H. BIXBY, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1890, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

IMPROVEMENTS.

1. Roanoke River, North Carolina and Virginia.
2. Pamlico and Tar rivers, North Carolina.
3. Contentnia Creek, North Carolina.
4. Trent River, North Carolina.
5. Neuse River, North Carolina.
6. Inland water-way between New Berne and Beaufort, North Carolina.
7. Harbor at Beaufort, North Carolina.
8. Inland water-way between Beaufort Harbor and New River, North Carolina.
9. New River, North Carolina.
10. Black River, North Carolina.
11. Cape Fear River, above Wilmington, North Carolina.
12. Cape Fear River, at and below Wilmington, North Carolina.
13. Yadkin River, North Carolina.
14. Harbor at Georgetown, South Carolina.
15. Winyaw Bay, South Carolina.

EXAMINATIONS AND SURVEYS.

16. Roanoke River, Virginia, from Clarksville to Eaton's Falls.
17. Fishing Creek, North Carolina.
18. North East River (Cape Fear), North Carolina.
19. Shallotte River, North Carolina.

UNITED STATES ENGINEER OFFICE,
Wilmington, N. C., July 8, 1890.

GENERAL: I have the honor to transmit herewith annual reports for the fiscal year ending June 30, 1890, upon the works of river and harbor improvements then in my charge.

Very respectfully, your obedient servant,

WILLIAM H. BIXBY,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

M 1.

IMPROVEMENT OF ROANOKE RIVER, NORTH CAROLINA, AND VIRGINIA.

HISTORY OF OPERATIONS.

(1) *Reference to past reports.*—For estimates of cost of improvement and for special description of river below Weldon, see pages 726–733, Annual Report for 1872, and page 1022 of Annual Report for 1884; and for the river above Weldon, see page 1060, Annual Report of 1882, and page 960 of Annual Report for 1887. (See, also, Appendix 16) (Examinations and Surveys), of 1890, Annual Report).

(2) *Original condition.*—The Roanoke River, entering into the Albemarle Sound, has with its tributaries a total length of about 400 miles and a drainage area of 9,200 square miles (2,050 of which are situated below the confluence of its two main tributaries, the Dan and Staunton).

When placed under governmental improvement, in 1872, this stream possessed a 10-foot depth of channel from its mouth 62 miles up to Hamilton, thence a 5-foot depth 67 miles further to Weldon (about 8 months per year), this channel depth being reduced during the low-water season to 10 feet to Hamilton and 2 feet to Weldon. Over the whole 129 miles, the river was more or less obstructed by snags, fallen trees, rocky bars, and by war obstructions. Its commerce, carried by steam-boat navigation, was estimated to have then been about $3,500,000.

(3) *Plan of improvement.*—The original projects of 1872 for below Weldon, and of 1882 for above Weldon, contemplated the removal of the war blockades, a few rocky bars, and all sunken logs, snags, floating and other obstructions, and the contraction of the channel-way by jetties so as to assure during the entire year an unobstructed 10-foot navigation up to Hamilton, and 5-foot navigation up to Weldon; and the clearing of a channel of 35 feet width and 2½ feet depth at low water for pole-boats from Eaton's Falls (12 miles above Weldon) 56 miles upward to Clarksville, Va. A personal examination of the river in 1888 revealed the agricultural richness of the whole river basin, its need of free transportation facilities, and the worthiness of the improvement below Weldon.

The total final cost of this work below Weldon was estimated in 1872 at $269,000 for a steam-boat channel of 5 feet depth at low water; and of the work above Weldon (from Eaton's Falls to Clarksville) was estimated in 1889 at $280,000, for the smallest useful pole-boat channel.

The aggregate amount appropriated for these projects up to June 30, 1890, is $113,000.

The funds now on hand will be nearly all used up before new appropriations can become available.

(4) *Results.*—Up to June 30, 1889, a total of $81,456.81 had been spent, in all, upon this improvement, giving a moderately well-cleared channel over the entire length of the river, allowing a 10 foot navigation 62 miles to Hamilton, and a 2-foot navigation 67 miles further to Weldon all the year; and also a fairly well-cleared 5-foot navigation all the way to Weldon during eight months of the year.

Fifteen steam-boats were then running on the river, and the river commerce had increased up to (in poor years) about $8,000,000, and (in good years) about $14,000,000, of goods transported per year, showing that each dollar once spent on this improvement has been accompanied by the development of about $100 of annual commerce.

The navigation of this river was not obstructed by bridges without draws.

(5) *Work of past year.*—The special work of the year is as follows: Expenditures, $20,578.01; value of United States plant, $6,575.

During the year one United States steam-hoister, one small steam-launch, two small floating hand-winches and other plant were in use.

Owing to the difficulty and expense of properly specifying it beforehand, and measuring it afterwards, all work was, for advantage and economy, done by hired labor and purchase of materials in open market.

During the year detailed surveys have been made as follows: By Assistant Engineer E. D. Thompson (whose report is herewith appended), at Weldon, from Old Weldon Landing to a point about 1,000 feet below the piers of the old railroad bridge; at Halifax (119 miles above river mouth), of the rock obstructions near the landing; at Looking Glass Shoal (103 miles above river mouth); at Big Rocky Bar (95 miles above mouth), and at Little Rocky Bar (97 miles above mouth). By Overseer Charles Schuster, at Shad Island Bend (29½ miles above mouth), and at Cader's Eddy (32½ miles above mouth).

From October 9, 1889, to June 30, 1890, one dredge, the *Nannie*, hired under agreement dated September 2, 1889, from Joseph Baker, of Berkley, Va., has been at work on the obstructions in the river.

This dredge worked at Little Rocky Bar from October 9, 1889, to October 17, 1889, and from December 22, 1889, to April 1, 1890, all inclusive, and completed a channel through the bar 184 feet wide and 5 feet deep at dead low water. The material excavated was deposited either on the banks of this cut or in the river below the shoal where it would not interfere with navigation.

This material consisted of sand mixed with hard blue clay, of pebbles, many small bowlders and a few large bowlders. Total amount of material excavated was as follows:

	Cubic yards.
Clay and sand	13,527
Pebbles and bowlders	1,717
Total	15,234

The cost of this dredging (including cost of dredge and working party while laid up by freshets, all superintendence, and also $300 for clerical and office force at Wilmington office) was $4,648.59, or 30.5 cents per cubic yard of material removed. A special report on the work at this locality was submitted on May 8, 1890.

From October 17, 1889, to December 21, 1889, and from April 2 to June 30, 1890, the *Nannie* has been at work at Big Rocky Bar. (This work was completed on July 3, 1890.)

The material removed, consisting of sand, coarse gravel, and bowlders, has been deposited on both banks of the cut. The cut when completed will be 138 feet wide and 5 feet deep at dead low water.

Total amount of material removed to June 30, 1890:

	Cubic yards.
Mud and sand	16,115
Gravel and bowlders	10,833
Total	26,948

Total cost up to June 30, 1890, $9,647.38, or 35.8 cents per cubic yard of material excavated.

Bank trimming has been done thoroughly from Indian Highland Bar to Quitsney (19 miles) and all the worst obstructions have been removed from the bends between Hamilton and Jamesville (44 miles).

To assist in this work, a small hoister and engine were borrowed from the Neuse River improvement.

Snagging has been done when possible, and the channel is now comparatively well cleared.

During the year there were removed from the banks: 4,923 trees cut and pulled back, 164 trees trimmed, 313 cords of brush cut; from the channel, 105 large snags, 54 logs, 242 stumps, 22 cords small snags.

Near the piers of the old railroad bridge, about 1 mile below Weldon, all projecting rocks were blasted and removed to the general level of the bottom.

At Halifax Landing all rock obstructions were blasted, but the work of removing this rock has been postponed to await a favorable stage of water.

On February 27, 1890, a project was submitted for a cut-off to be made at Shad Island Bend. This project was approved by indorsement from the office of the Chief of Engineers, dated May 14, 1890. The trees and stumps have already been removed from the site of the proposed cut, and the cutting will be begun as soon as the dredge finishes work at Big Rocky Bar.

Three water-gauge records were kept during the year.

Inspections of property and progress of work were made during the year.

Work during the year has been considerably interfered with by unusually and excessively high water.

The work of this improvement during the year was well and efficiently carried on under the immediate supervision of Overseer Charles Schuster, whose report is herewith appended.

The work of the past year has much improved the navigable condition of the river over its entire length, and the commerce is steadily increasing.

The dredged channels at Big and Little Rocky bars now permit steamers drawing 5 feet to ascend the river to Weldon at ordinary low water. The worst obstructions have been removed from the channel, and the removal of overhanging trees, brush, etc., has much facilitated the passage of the worst bends on the river.

Late work upon the various bars of the river has been so much less expensive than anticipated, that it is probable a single further appropriation of $40,000 will complete all work at present advantageous on this river; but definite statements on this subject should await the result of further surveys and examinations during the next low-water season.

The railroad bridge of the Norfolk and Carolina Railroad across the river near Powell's Barn (94 miles above river mouth) has been completed and provided with a suitable draw.

Otherwise the situation remains about the same as at the beginning of the fiscal year.

The latest reliable commercial statistics, those for the year ending December 31, 1889, are herewith appended, showing a commerce of $4,986,000 per year (about 159,700 tons).

(6) *Recommendations for future work.*—It is recommended that this improvement be completed in accordance with the original projects, so as to secure a thoroughly-cleared 10-foot navigation up to Hamilton, and a similar 5-foot navigation to Welden, during the entire year, at a total expense of $156,000, if necessary, in addition to the funds available June 30, 1890, this amount to be appropriated in yearly installments of as much as $60,000 each. Smaller yearly appropriations, involving the

alternate disorganization and reorganization of working parties, damage to unfinished work, extra superintendence, and the deterioration of plant may increase the cost of the work by from $2,000 to $6,000 per appropriation. Further improvement, so as to extend the navigation above Weldon, or so as to increase the depth of water or length of time of such navigation below Weldon is not recommended at present.

After the improvement is finished, its proper maintenance may cost from $2,000 to $6,000 per year.

This river is in the collection district of Albemarle, and the nearest port of entry is Edenton, N. C. The nearest light-house is the Roanoke River Light.

Six maps.

Money statement.

July 1, 1889, amount available		$31,543.19
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$19,006.97	
July 1, 1890, outstanding liabilities	1,571.04	
		20,578.01
July 1, 1890, balance available		10,965.18
Amount appropriated by act of September 19, 1890		25,000.00
Amount available for fiscal year ending June 30, 1891		35,965.18
Amount (estimated) required for completion of existing project		131,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		60,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

REPORT OF MR. E. D. THOMPSON, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Wilmington, N. C., June 30, 1890.

CAPTAIN: I have the honor to submit the following report of work done under my charge on the Roanoke River, North Carolina and Virginia, during the fiscal year ending June 30, 1890.

In accordance with instructions of July 7, 1889, detailed examinations and surveys were made at the following localities, viz: Big Rocky Bar, Little Rocky Bar, Looking Glass Bar, Halifax Bar, and Weldon Bar, with reference to the location of a channel, to be dredged (or blasted) at each locality, so as to secure a depth of 5 feet at dead low water.

An attempt was made in July, 1889, to survey Big Rocky Bar, but a freshet coming on, work was postponed until a more favorable stage of water. The surveys were finally begun on August 22, and continued without intermission until September 9, when they were completed.

Full and complete field maps, showing all details of shoals and channels and the character of the bottom, were submitted as each survey was completed.

Surveys were based on compass directions and stadia distances; soundings were taken with a graduated rod up to depths of 16 feet (lead and line being used for greater depths), and located by direct measurement by means of a tagged cord stretched across the river. All work was plotted in the field and the maps carefully compared with the ground, so as to fully determine all uncertain points in contours as indicated by soundings, and the widths and extent of natural channels not fully covered by range lines. Borings were also made at different points in the river-bed to determine the character of material that might have to be removed.

At each locality a low-water datum, with properly-marked bench-marks, was established for the use of the local overseer.

The expenditures for the assistant engineer and rodman, for field and office work, were $301.59. Overseer Charles Schuster furnished all the ordinary labor, the use of the tug *Nell*, and personally rendered much assistance during the progress of the work.

Very respectfully, your obedient servant,

E. D. THOMPSON,
Assistant Engineer.

Capt. W. H. BIXBY,
Corps of Engineers, U. S. A.

REPORT OF MR. CHARLES SCHUSTER, OVERSEER.

UNITED STATES ENGINEER OFFICE,
Scotland Neck, N. C., June 30, 1890.

CAPTAIN: I have the honor to make the following report of operations upon the improvement of the Roanoke River, North Carolina and Virginia, during the fiscal year 1889–'90.

During the year the following detailed surveys have been made by Mr. E. D. Thompson, United States assistant engineer: At Weldon, from Old Weldon Landing to about 1,000 feet below the piers of old railroad bridge; at Halifax, of the rocky shoals near the landing; at Looking Glass Bar; at Big and Little Rocky Bars.

Shad Island Bend and Cader's Eddy have also been surveyed by me.

Near the piers of the old railroad bridge, about 1 mile below Weldon, all projecting rocks were blasted and removed to the level of the general surface of the bottom.

At Halifax Landing all projecting rocks were blasted, but owing to the many freshets of unusual height and long duration the work of removing the rock blasted was postponed until the low-water season, when this work may be done more advantageously and cheaper.

The rock-work at Weldon and Halifax was frequently interrupted by freshets, during which time the men were employed in bank trimming below Hamilton.

Under an agreement dated September 2, 1889, made by you with Jos. Baker, of Berkley, Va., the scoop-dredge *Nannie* was hired to dredge a channel 5 feet deep at dead low water through Big and Little Rocky Bars. The *Nannie* started work at Little Rocky Bar October 8, 1889, and after cutting a channel 46 feet wide and 5 feet deep at dead low water there, moved to Big Rocky Bar and cut a channel there of the same width and depth, after which she moved back to Little Rocky Bar, and completed the channel there to its present dimensions, viz: 184 feet wide and 5 feet deep at dead low water. The material removed consisted chiefly of a very stiff clay mixed with sand and small bowlders. It was mostly dumped on the right bank on the shoal below the point. This work practically removes Little Rocky Bar (to the depth mentioned), as the bar is dredged out for the full width of the river there available for navigation.

The cost of dredging at Little Rocky Bar was $4,648.59, including towage, superintendence, and $300 for clerical expenses in Wilmington office, etc., or 30.5 cents per cubic yard. The original estimate for this work was $10 per cubic yard. (See annual report of Mr. S. T. Abert, United States Agent, for 1887, page 956.)

The amount of material removed was: Clay and sand 13,517 cubic yards; pebbles and bowlders 1,717 cubic yards; total 15,234 cubic yards.

The scows being too large to be towed by the small Government launch on this river, they were handled by the hoister *Roanoke*, on the principle of a pendulum ferry. The average delay to the dredge, caused by shifting scows in this manner, was four minutes.

At Big Rocky Bar the work of dredging was then continued and a channel 115 feet wide and 5 feet deep at dead low water was dredged through this bar. Twenty-six thousand nine hundred and forty-eight cubic yards of material have been removed, chiefly coarse gravel and sand mixed with bowlders, and most of this material has been dumped on the right bank of the river abreast of the channel, and about one, fourth on the left bank. The dump on the right bank has been leveled and thrown still farther towards the bank by shovels, when the stage of water permitted. Thus the general bed of the river has been narrowed considerably and the velocity of the current through the new channel increased, and it has been observed that the channel is scouring deeper already, especially near the lower end.

The cost of dredging at this bar was $9,647.38, or 35.8 cents per cubic yard, including towage and superintendence, the estimate for the same work in 1887 being $3 per cubic yard.

Bank trimming has been done thoroughly from Indian Highland Bar to Quitsney-and all the worst obstructions have been removed from the bends between Hamilton and Jamesville (44 miles).

The small hoister which has been constructed from a lighter scow, and a small boiler and engine obtained temporarily from the Neuse River works, is very convenient for this work. The number of obstructions removed from the banks during the year was:

Trees cut and hauled back	4,923
Trees trimmed	164
Brush cut (cords)	313

Snagging was done at such times when the hoister *Roanoke* was not employed assisting the dredge, and the obstructions removed were:

Large snags	105
Logs	54
Stumps	254
Small snags (cords)	22

SHEET 1

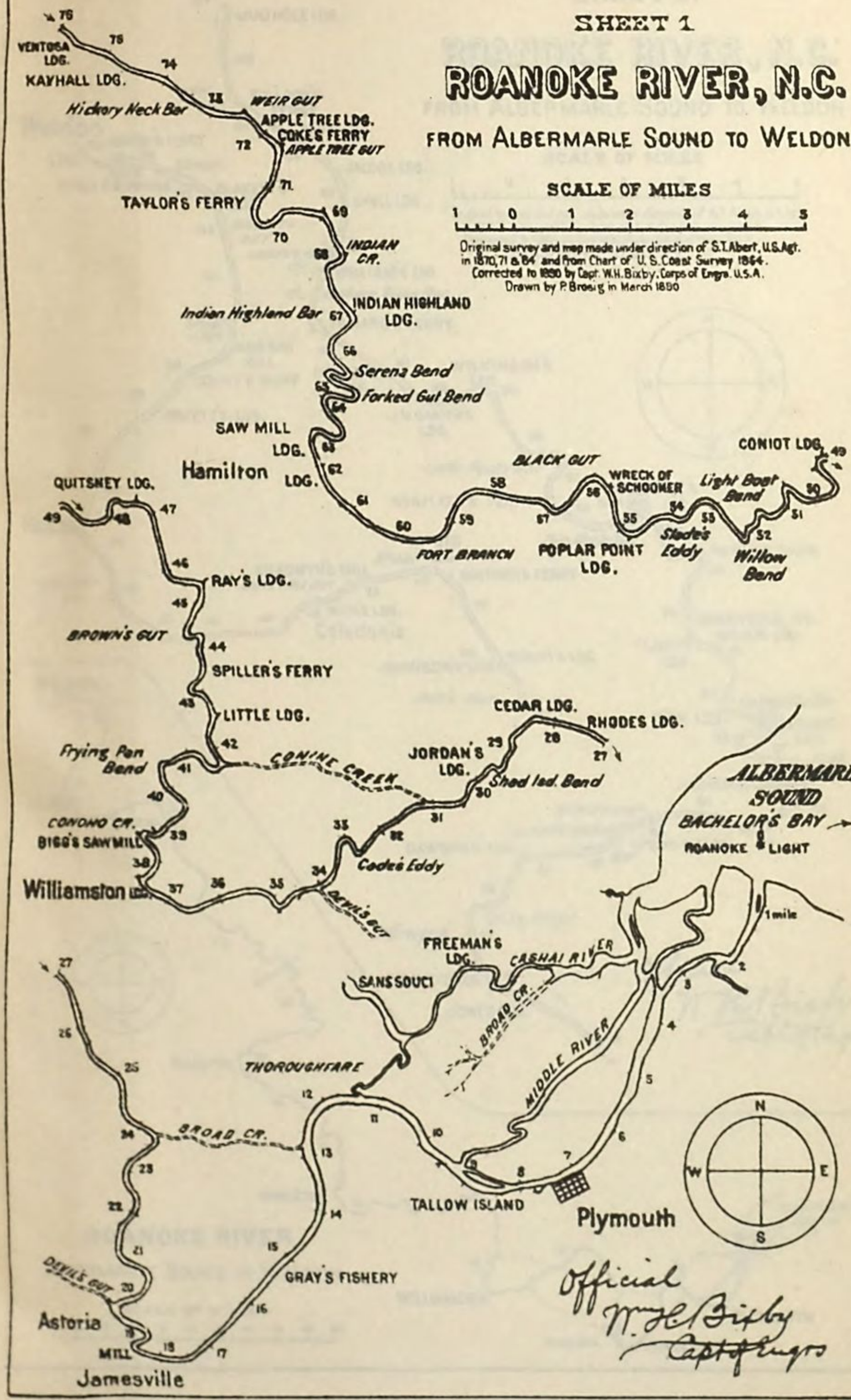
ROANOKE RIVER, N.C.

FROM ALBERMARLE SOUND TO WELDON

SCALE OF MILES

1 0 1 2 3 4 5

Original survey and map made under direction of S.T.Abert, U.S.Agt. in 1870, 71 & '84 and from Chart of U. S. Coast Survey 1864. Corrected to 1880 by Capt. W.H. Bixby, Corps of Engrs. U.S.A. Drawn by P. Broeig in March 1880



Official
Wm. H. Bixby
Capt. Engrs

Eng 90

SHEET 2.

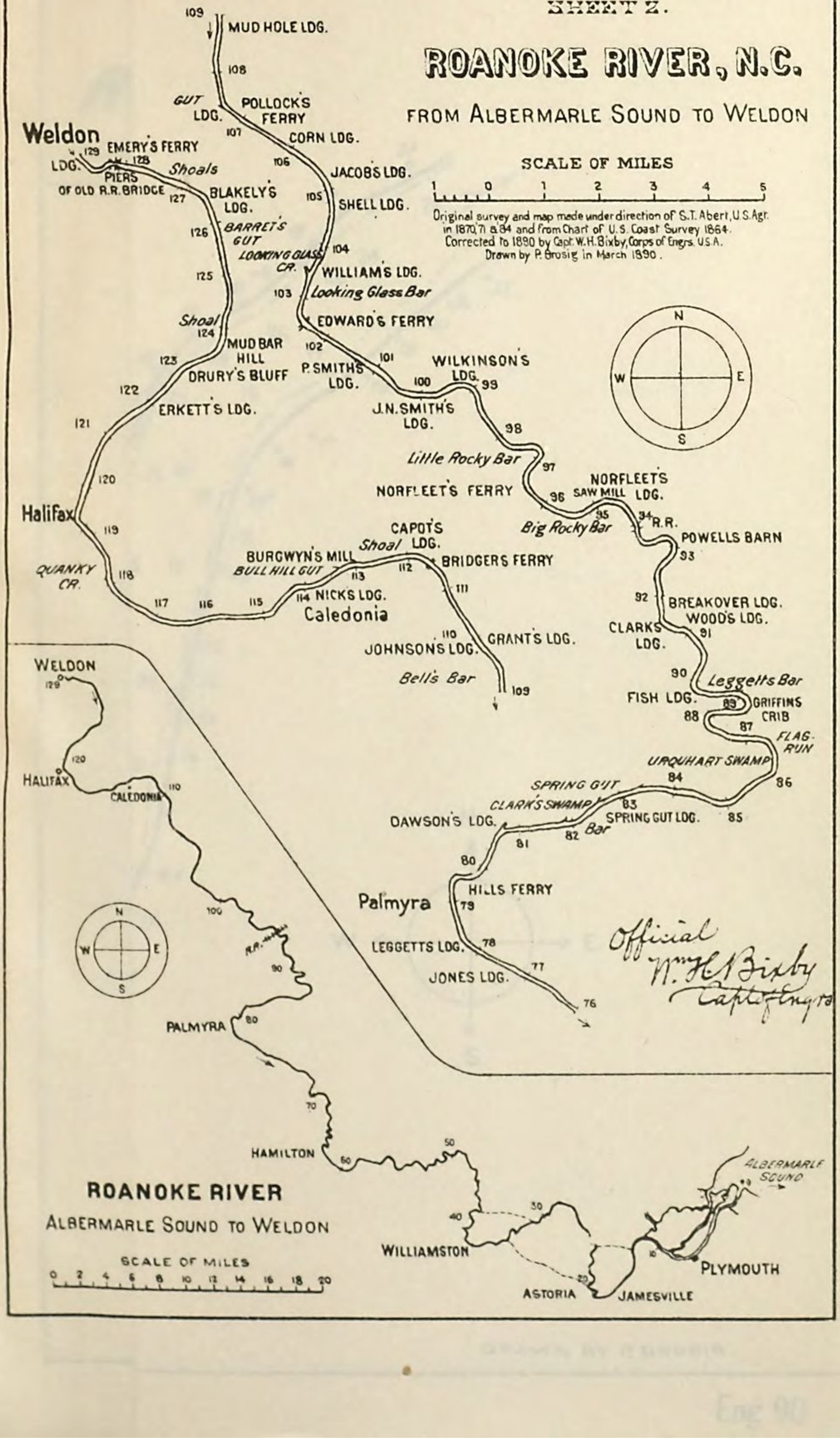
ROANOKE RIVER, N.C.

FROM ALBERMARLE SOUND TO WELDON

SCALE OF MILES

1 0 1 2 3 4 5

Original survey and map made under direction of S.T. Abert, U.S. Agr. in 1870, '71 & '84 and from Chart of U.S. Coast Survey 1864.
Corrected to 1890 by Capt. W.H. Bixby, Corps of Engrs. U.S.A.
Drawn by P. Grosig in March 1890.



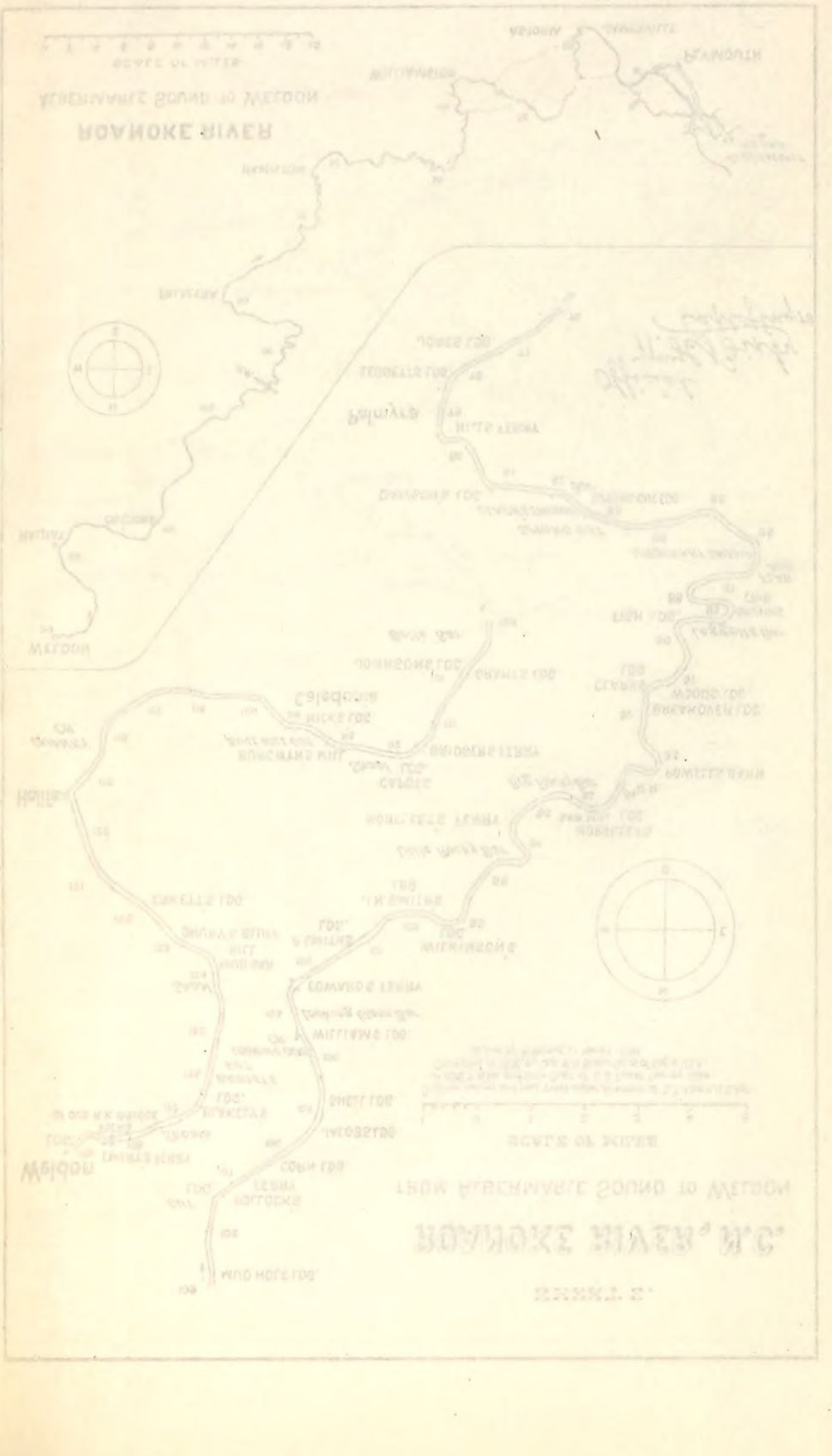
Official
W.m H. Bixby
Capt. Engrs

ROANOKE RIVER

ALBERMARLE SOUND TO WELDON

SCALE OF MILES

0 2 4 6 8 10 12 14 16 18 20



ROANOKE RIVER, N.C.

SHEET Nº3.

SHAD ISLAND BEND

29.5 MILES ABOVE MOUTH OF RIVER

SCALE

100 0 100 200 300 400 500 600 700 800 FEET.

Based on map of Chas. Schuster - 1890.
Surveys made under direction of Capt. W.H.Bixby, U.S.Engrs.

18 ° ° 20 SURVEY STAKES

13 37 DEPTHS BELOW DEAD LOW WATER (FT.).

+7 +8 HEIGHTS ABOVE " " " " .

10 FT. CONTOUR AT DEAD LOW WATER.

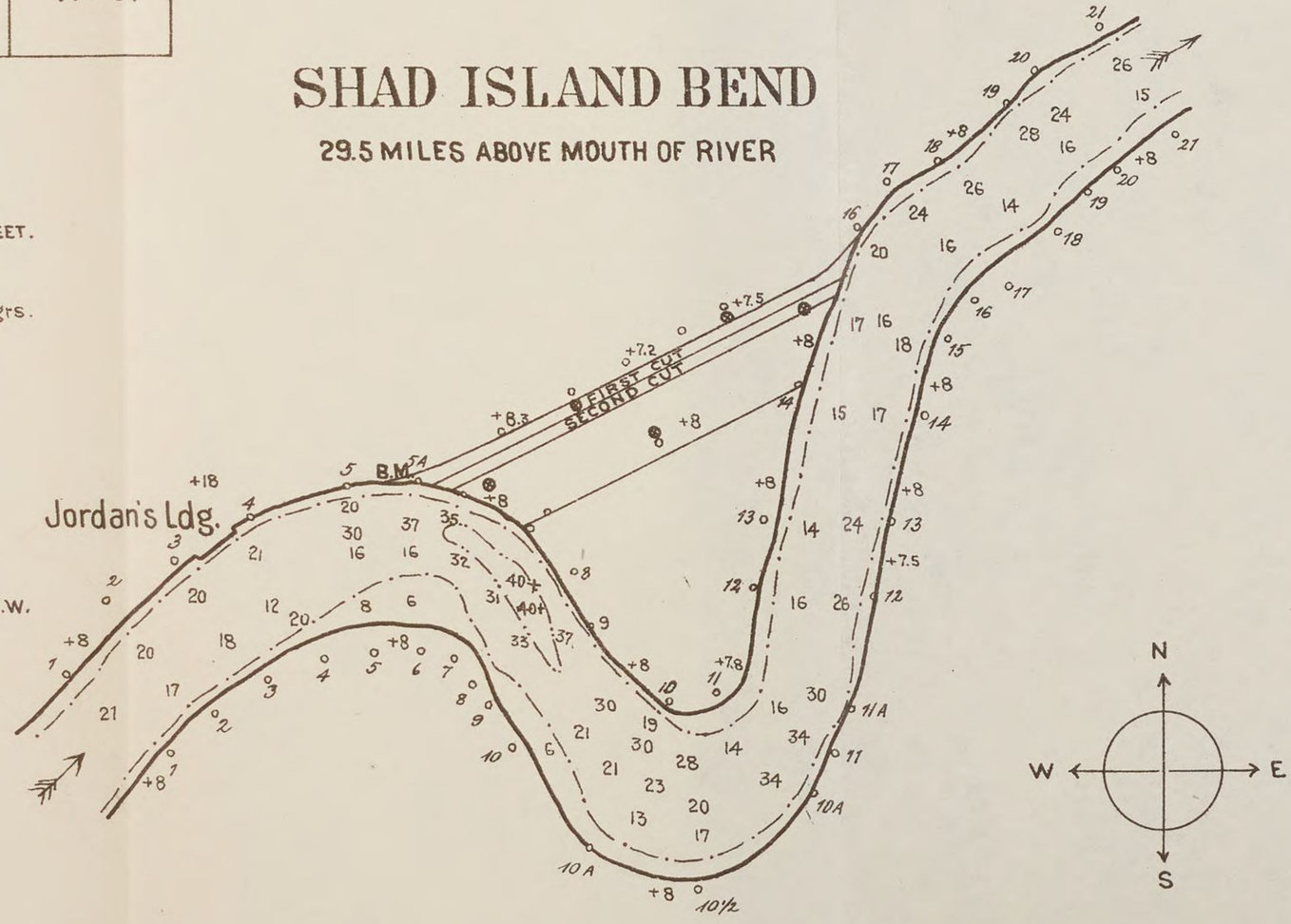
40 " " " " " " .

PROPOSED CHANNEL

B.M. BENCH MARK ON CYPRESS TREE, 8 FT. ABOVE D.L.W.

BORINGS, 17 FT. DEEP. — MUD & SAND.

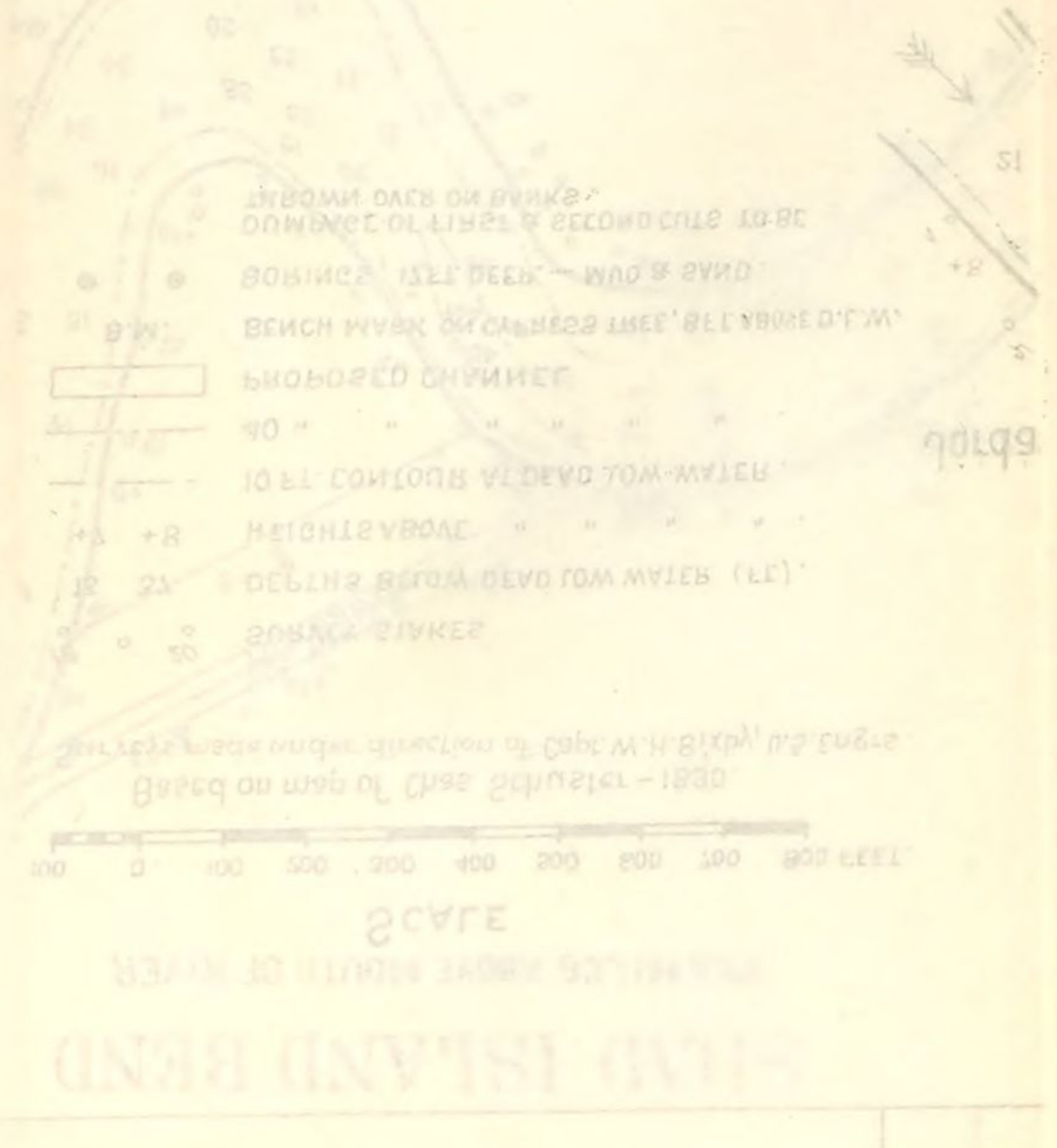
DUMPAGE OF FIRST & SECOND CUTS TO BE THROWN OVER ON BANKS.



Official
Wm. H. Bixby
Capt. Engrs

DRAWN BY F. BROSIG.

Eng 90



No. 2.
SHEET

PROGRESS MAP FOR 1890

ROANOKE RIVER, N.C.

FROM 1. JULY 1889 TO 30. JUNE 1890.

SHEET Nº 4.

SCALE

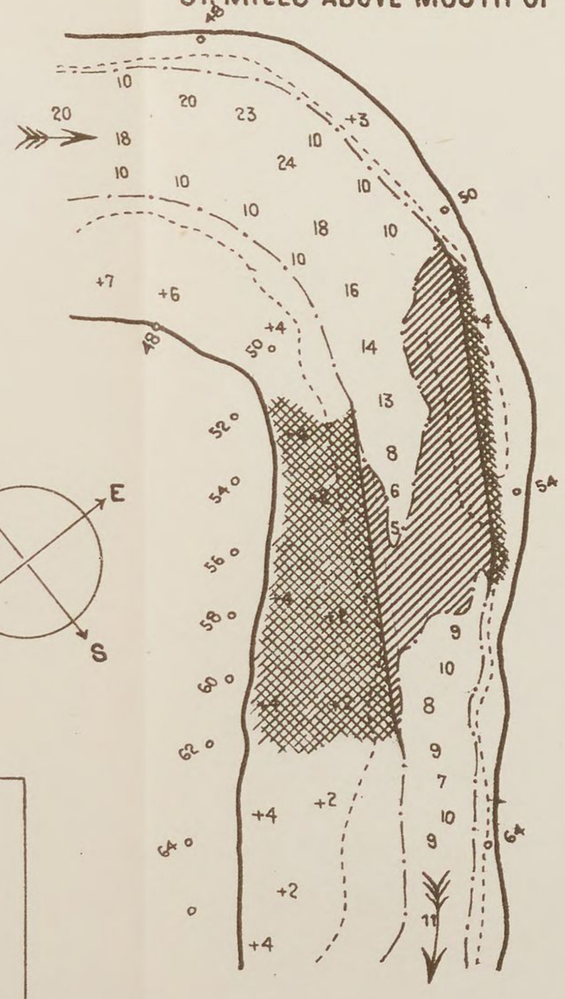
100 0 100 200 300 400 500 FEET.

Based on map of E.D. Thompson - 1889.
Surveys made under direction of Capt. W.H. Bixby, U.S. Engrs.

- SURVEY STAKES
- DEAD LOW WATER LINE
- 3 FT. CONTOUR AT DEAD LOW WATER
- DREDGING OF PREVIOUS YEARS
- DREDGING OF FISCAL YEAR 1889/90 TO 5.5 FT. DEPTH AT DEAD LOW WATER.
- UNCOMPLETED CHANNEL
- DUMPAGE
- 10 24 FT. - DEPTHS BELOW D.L.W.
- +1 +8 FT. - HEIGHTS ABOVE D.L.W.

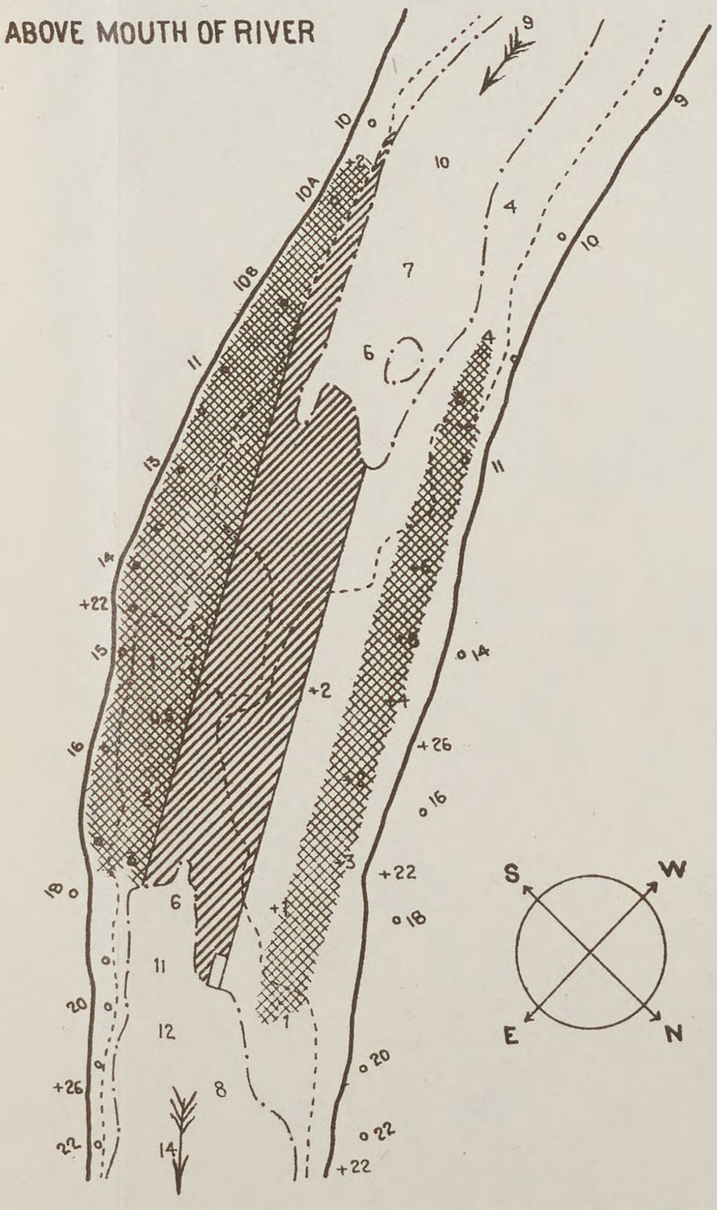
LITTLE ROCKY BAR

97 MILES ABOVE MOUTH OF RIVER.



BIG ROCKY BAR

95 MILES ABOVE MOUTH OF RIVER



Wilmington N.C. *July 1890.*

Respectfully submitted

W. H. C. Bixby

CAPTAIN OF ENGINEERS

DRAWN BY P. BROSIG.

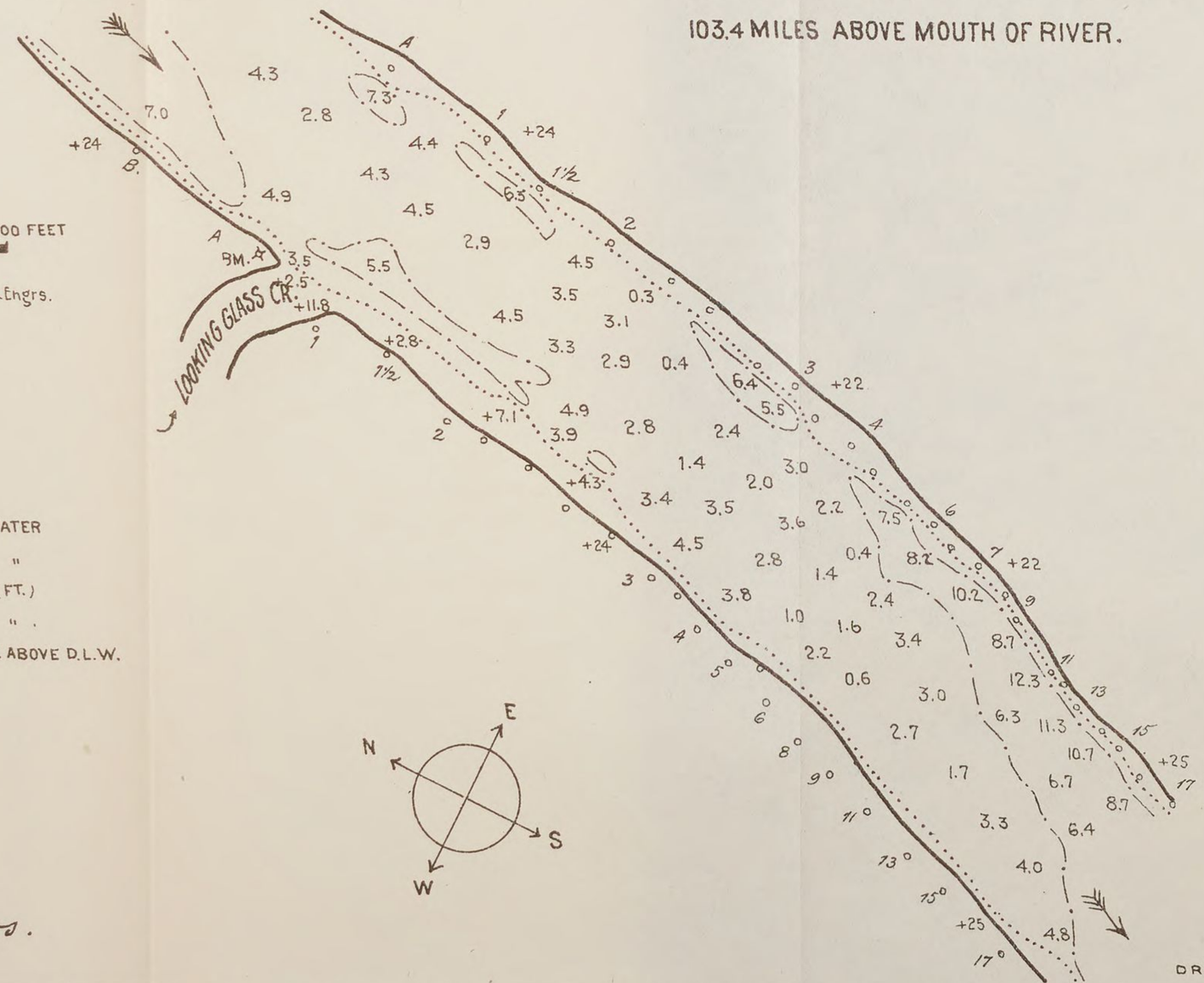
N
E
W
S

ROANOKE RIVER, N.C.

SHEET No 5

LOOKING GLASS BAR

103.4 MILES ABOVE MOUTH OF RIVER.



SCALE

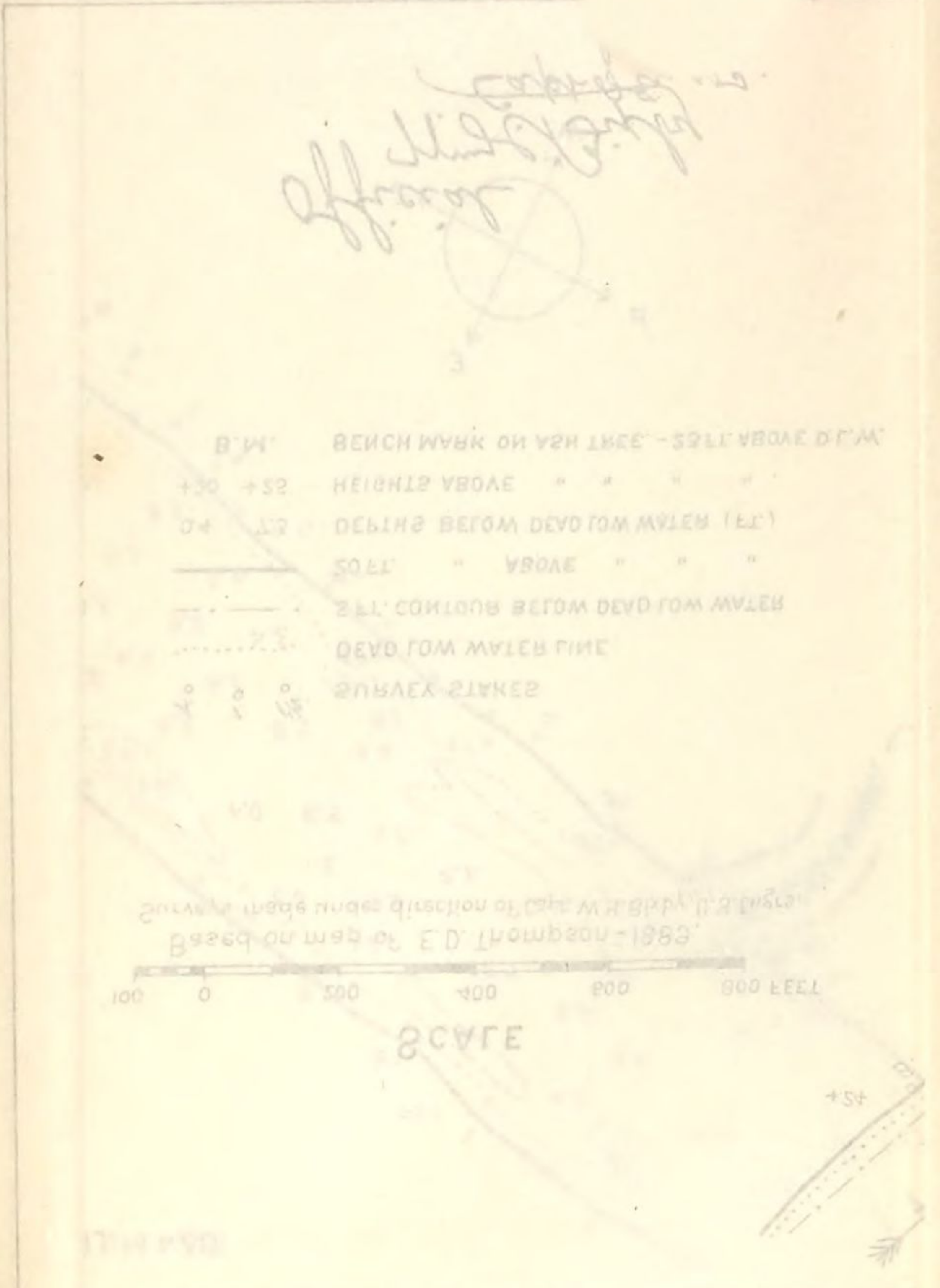
100 0 200 400 600 800 FEET

Based on map of E.D. Thompson – 1889.
Surveys made under direction of Capt. W.H. Bixby, U.S. Engrs.

1. 7. 1½. SURVEY STAKES
..... DEAD LOW WATER LINE
— · — · 5 FT. CONTOUR BELOW DEAD LOW WATER
——— 20 FT. " ABOVE " " "
0.4 7.3 DEPTHS BELOW DEAD LOW WATER (FT.)
+20 +25 HEIGHTS ABOVE " " " " .
B.M. BENCH MARK ON ASH TREE. – 23 FT. ABOVE D.L.W.

Official
W. H. C. Bixby
Capt. of Engrs.

DRAWN BY P. BROSIG.



PROGRESS MAP FOR 1890.

ROANOKE RIVER, N.C.

FROM 1. JULY 1889 TO 30. JUNE 1890.

SHEET No 6.

HALIFAX BAR

119.4 MILES ABOVE MOUTH OF RIVER.

BAR AT OLD R.R. BRIDGE PIERS

128. MILES ABOVE MOUTH OF RIVER.

SCALE

100 0 200 400 600 FEET

Based on map of E.D. Thompson - 1889
Surveys made under direction of Capt. W.H. Bixby, U.S. Engrs.

24 ° ° 26 SURVEY STAKES
DEAD LOW WATER LINE
5 FT. CONTOUR AT DEAD LOW WATER
BLASTING OF FISCAL YEAR 1889/90.
PROPOSED CHANNEL
4.6 1.2 FT. - DEPTHS BELOW D.L.W.
+50 +20 FT. - HEIGHTS ABOVE D.L.W.

Ferry Ldg.

Ferry Ldg.

Ferry Ldg.

Old R.R. Bridge Piers.

Weldon - Lower Ldg.

GUT

ROCK

N W E S

Wilmington, N.C. *July 1890.*

Respectfully submitted

Wm. H. Bixby

CAPTAIN OF ENGINEERS

DRAWN BY P. BROSIG.

Eng 90

PROGRESS MAP FOR 1890.

ROANOKE RIVER, N.C.

FROM JULY 1889 TO 20 JUNE 1890.

Respectfully submitted

Wilmington N.C. July 1890

CAPTAIN CRE

Based on map of E.D. Thompson - 1883

Survey made under direction of Capt. W.H. Bixby U.S. Engrs.

SCALE

100 0 500 400 800 FEET

SURVEY STAKES

DEAD LOW WATER LINE

5 FT. CONTOUR AT DEAD LOW WATER

BLASTING OF FISCAL YEAR 1889\90

PROPOSED CHANNEL

ET. - DEPTHS BELOW D.L.W.

ET. - HEIGHTS ABOVE D.L.W.

N

MILES

Though the river has undoubtedly been greatly benefited by the removal of the above obstructions, still there is very much work of the same character left to be done.

At Shad Island Bend the trees and stumps were removed from the area of the proposed channel preparatory to dredging.

During the past year the fifteen steamers plying on this river have run regularly and without a single accident. This alone speaks well for the work done to this river by the General Government, as herefore it was a frequent occurrence for steamers to be snagged and sunk to the great expense of the owners and the annoyance of the shippers.

Owing to the improvement of the river at Halifax, the steamer *Comet*, of the Baltimore, Norfolk and Roanoke Navigation Company, is now running frequently as high as the Convict farms, 4 miles below Weldon, and will make regular trips there as soon as the crop season opens.

Masters and pilots on this river are well pleased with the work done so far.

* * * * * * *

The crops on the high land last year were a total failure in this section, and all the crops in the rich river-bottom land were destroyed by the extraordinary high freshet of August–September, 1889.

Gauge observations were taken daily for the past year at Weldon, Norfleet's Ferry, and Jamesville.

The draw-bridge of the Norfolk and Carolina Railroad Company across the river near Powell's Barn, has been completed and trains have crossed regularly since April 1, 1890.

Very respectfully, your obedient servant,

CHAS. SCHUSTER,
Overseer.

Capt. W. H. BIXBY,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

When work commenced in 1872, the river was badly obstructed by leaning trees, snags, rocky bars, and war obstructions.

Its commerce is estimated to have then been $3,500,000 of goods transported per year.

Eight large river steamers of 6 to 9 feet draught are now constantly using the lower part of the river, and one light-draught steamer makes two trips per week on the upper river to within a few miles of Weldon. The present rates of freight are very much lower than in 1872, and river marine insurance is now very small.

The failure of the cotton crop of last year caused a considerable falling off in the total commerce of the river.

The lumber business is steadily increasing.

The commerce for the year ending December 31, 1889, is estimated as follows:

Class of goods.	Exports.	Imports.	Totals.
Cotton and products	$1,500,000	.....	$1,500,000
Tobacco	.....	$17,000	17,000
Rice	15,000	16,500	31,500
Grains and forage	.....	372,500	372,500
Vegetables and truck	40,000	.....	40,000
Live stock and products	500	.....	500
Fish, oysters, etc	45,000	22,000	67,000
Naval stores	1,500	.....	1,500
Lumber and products	800,000	.....	800,000
Coal and minerals	.....	5,000	5,000
Fertilizers	.....	460,000	460,000
Machinery	.....	85,000	85,000
General merchandise	100,000	1,506,000	1,606,000
Sundries	.....	.....	.....
Total	2,502,000	2,484,000	4,986,000

Approximate tonnage, 159,700 tons.

No new transportation lines established during year.

The above statistics are based mainly upon the reports of Lieutenant Patrick and Overseer Charles Schuster made after much correspondence and conversation with

steam-boat captains and agents, custom-house officials, and prominent shippers and merchants.

The commerce at present, as above shown, is (159,700 tons)	$4,986,000
The commerce before the improvement began was	3,500,000
The development of commerce since beginning of improvement is	1,486,000
Expended on improvement up to December 31, 1889	90,280
The development of annual commerce for every dollar spent on the improvement is	16

M 2.

IMPROVEMENT OF PAMLICO AND TAR RIVERS, NORTH CAROLINA.

HISTORY OF OPERATIONS.

(1) *References to past reports.*—For special description of Pamlico River, see pages 361–363, Annual Report for 1876, and pages 1130–1132, Annual Report for 1889; for history of work, see pages 649–651, Annual Report for 1879; and for map of river, see page 836, Annual Report for 1880. For special description of Tar River, see pages 700–702, Annual Report for 1879; and for map of river, see page 1,012, Annual Report for 1887.

(2) *Original condition.*—The Pamlico and Tar rivers are different portions of a single stream, the upper portion being called the Tar. The Tar has a total length of about 180 miles and a drainage area of 3,200 square miles, and changes its name to the Pamlico at the town of Washington, N. C. The Pamlico has a further length of about 37 miles and a further drainage area of 1,700 square miles, and finally widens out into Pamlico Sound. The combined rivers, therefore, have a total length of about 217 miles and a total drainage area of about 4,900 square miles.

When placed under governmental improvement in 1876, the Pamlico River had an available depth of only 3 feet at low water in its upper portion near Washington; thence the Tar River had during eight months of the year an available depth of from 2 to 3 feet for 49 miles, up to Tarborough its practicable limit of navigation; but the channel of the combined stream was almost completely obstructed by two war blockades and by floating and sunken stumps and logs and by overhanging trees. Its steam-boat commerce is now estimated to have then been about $500,000.

(3) *Plan of improvement.*—The two rivers have been considered by Congress, separately prior to 1880, but jointly ever since then. The original project of 1876 (for the Pamlico) and of 1879 and 1889 (for the Tar), as since slightly modified and continued to date, proposed to secure a clear and safe channel 9 feet deep at low water up to Washington; thence a channel 60 feet wide and 3 feet deep at low water for 23 miles farther to Greenville; and thence a channel 60 feet wide and 20 inches deep at low water for 26 miles farther to Tarborough and Rocky Mount Little Falls. A personal inspection of the river in 1886 showed the agricultural richness of the river basin, its need of water transportation, and the worthiness of the improvement.

The total final cost of this work was estimated in 1889 to be $92,200.

The total amount appropriated for these projects up to June 30, 1890, is $68,000.

The funds on hand will be used up before new appropriations can become available.

(4) *Results.*—Up to June 30, 1889, a total of $64,608.53 had been spent in all upon this improvement; in securing a good channel at least 9 feet deep at low water and at least 108 feet wide from Pamlico Sound, 37 miles, up to Washington; thence a fair channel 60 feet wide and 3 feet deep all the year for 23 miles to Greenville; and thence a similar channel eight months of the year for 26 miles to Tarborough.

In consequence of this, 13 steamers ran regularly to Washington, thence 4 steamers ran three times a week all the year to Greenville, and eight months of the year to Tarborough. The present commerce was rapidly increasing and was then about $4,500,000 of goods transported per year, showing that each dollar once spent upon this improvement had been accompanied by a development of about $60 in annual commerce. Besides this, the rates of freight are estimated to have been lowered between 12 and 50 per cent. since the commencement of the improvement.

The navigation of this river was not obstructed by bridges without draws below Tarborough.

(5) *Work of past year.*—The special work of the past year is as follows: Expenditures, $1,619.37; value of plant, $1,880.

Owing to the difficulty of properly specifying it beforehand and measuring it afterwards, all work was, for advantage and economy, allowably done by hired labor and the purchase of materials in open market.

Active work was suspended in June, 1889, to await a more favorable stage of water for snagging.

While not needed on this river, its United States property was used for a time on the Neuse River, and then stored and cared for on that stream.

Water-gauges have been kept during the year.

Inspections of plant and work have been made during the year.

This improvement has been under the immediate supervision of Superintendent R. Ransom, whose report is herewith appended.

The existing fair navigable condition of the river below Tarborough has been maintained, and the 23 miles of the river above Tarborough heretofore opened have been used by steamers of 3-foot draught during 8 or 9 months of the year. The river commerce is steadily increasing.

A railroad bridge with suitable draw has been built across the river above Tarborough. Four bridges across the river at and above Tarborough, now without draws, will doubtless be provided with suitable draws as soon as the interests of navigation require them. Otherwise the situation remains about the same as at the beginning of the fiscal year.

The latest reliable commercial statistics, those for the year ending December 31, 1889, are herewith appended, showing a commerce of $4,670,810 per year (about 178,720 tons).

(6) *Recommendations for future work.*—It is recommended that this improvement be completed in accordance with the present proposed and approved project, so as to secure a thoroughly-cleared 9-foot navigation at low water up to Washington, a similar 3-foot navigation at low water up to Greenville, and thence a similar 3-foot channel during eight months of the year up to Little Falls, Rocky Mount, at a total expense of $24,200, in addition to the funds available June 30, 1890; this amount to be appropriated in yearly installments of as much as

$15,000 until finished. Smaller appropriations may increase the cost by from $1,000 to $3,000 per year. Further improvement so as to extend this navigation above Little Falls, Rocky Mount, or to make the river above Greenville navigable all the year round, is not recommended at present.

After the improvement is finished its proper maintenance may cost from $1,000 to $3,000 per year.

This river is in the collection district of Pamlico, N. C.

Money statement.

July 1, 1889, amount available		$3,391.47
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$1,517.92	
July 1, 1890, outstanding liabilities	101.45	
		1,619.37
July 1, 1890, balance available		1,772.10
Amount appropriated by act of September 19, 1890		10,000.00
Amount available for fiscal year ending June 30, 1891		11,772.10
Amount (estimated) required for completion of existing project		14,200.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		14,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. R. RANSOM, SUPERINTENDENT.

UNITED STATES ENGINEER OFFICE,
New Berne, N. C., May 20, 1890.

CAPTAIN: I have the honor to submit below annual report of operations for the improvement of Pamlico and Tar rivers, North Carolina, for the fiscal year ending June 30, 1890.

Owing to want of funds no active operations have been conducted.

* * * * * * *

Such yearly attention should be given to the improvements after they are completed as will enable those in charge of the works to prevent their deterioration or absolute destruction.

In my judgment $30,000 may be well and profitably expended upon this stream within the next fiscal year.

The past year was one of unprecedentedly small agricultural production, and the exports were greatly reduced, but the energy of the inhabitants and the capabilities of the soil, it is believed, will soon balance the unevenness that now exists.

Very respectfully, your obedient servant,

R. RANSOM,
Superintendent.

Capt. W. H. BIXBY,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

When work commenced in 1876, the river was irregularly navigated by 3-foot draught steamers up to Tarborough. The commerce is estimated to have then been about $500,000 of goods transported per year. The present commerce is about $4,600,000 of goods transported per year.

Thirteen steamers now ascend the river regularly 37 miles, to Washington, and four others make regular trips to Greenville, 23 miles farther, during the whole year, and 26 miles farther to Tarborough, during the flush-water season. One of the steamers that usually runs from Baltimore to Washington, N. C., has made a trip to Tarborough and return, without hindrance, drawing 6½ feet of water.

Three-masted schooners with cargoes of ice from the North have also been towed to Greenville to deliver cargoes without breaking bulk.

SHEET 1.

PAMLICO & TAR RIVERS, N.C.

FROM WASHINGTON TO TARBORO

SCALE OF MILES

1 ½ 0 1 2

Original survey and map made by P. Darling in 1882
Reduced and drawn in office of Captain W. H. Bixby, Corps of Engineers, U.S.A.
by P. Brosig, February 1890.
Surveys made under direction of Capt. J. Mercur, U.S. Engrs.

⚓ LANDINGS FOR BOATS

Official
W. H. Bixby
Capt. Engrs.

YANKEE HALL LDG.
LDG.
AVON LDG.
LDG.
LDG.
TARBORO
SPARTA
PENNY HILL
CENTER BLUFF
GREENVILLE
TAR RIVER
WASHINGTON
CHERRY'S LDG.
SUMMIT HILL
DIXON'S LDG.
TAFT'S LDG.
CHICOD CR.
BOYD'S FERRY
BLAKLEY'S FISHERY
GRIMES LDG
PANTHER CR.
FISHERY
CLARKS LDG.
FISHERY
TAR RIVER
MARTIN'S BAY
SHOP COVE
TRANTER CR.
KENNEDY CR.
BEAR CR.
W. & J. R.R. BRIDGE
SHORT'S MILL
1 MILE
Washington
WINDMILL CR.
RUNYON CR.
CASTLE
BATH
PUNGO R.
SLADESVILLE
PAMLICO RIVER
PAMLICO PT.
PAMLICO SOUND
RODMAN'S CR.
PAMLICO RIVER

N W E S

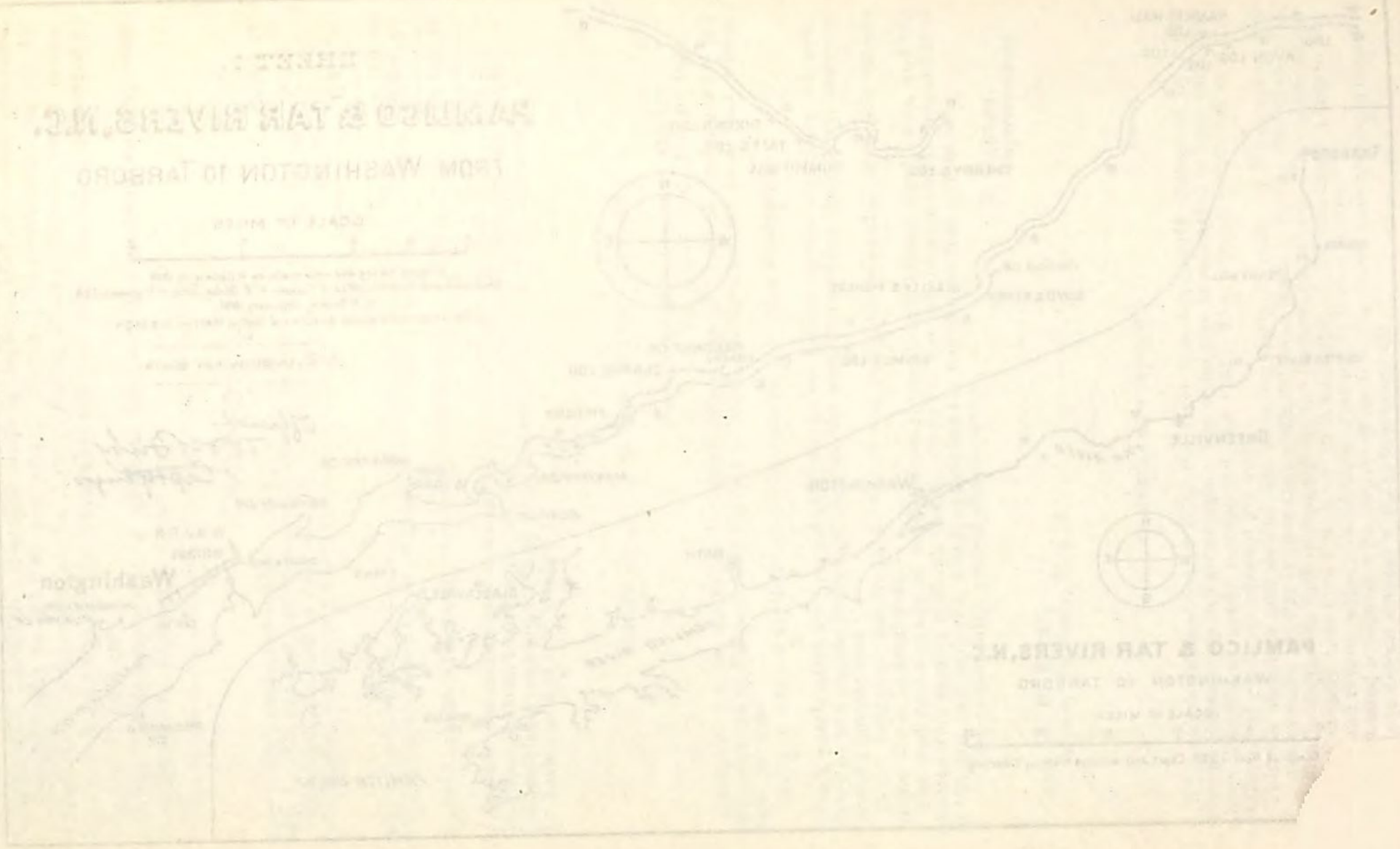
PAMLICO & TAR RIVERS, N.C.

WASHINGTON TO TARBORO

SCALE OF MILES

0 5 10 15 20 25

Compiled from U.S.C.S. Chart and surveys made by P. Darling.



SHEET 2.

PAMLICO & TAR RIVERS, N.C.

FROM WASHINGTON TO TARBORO

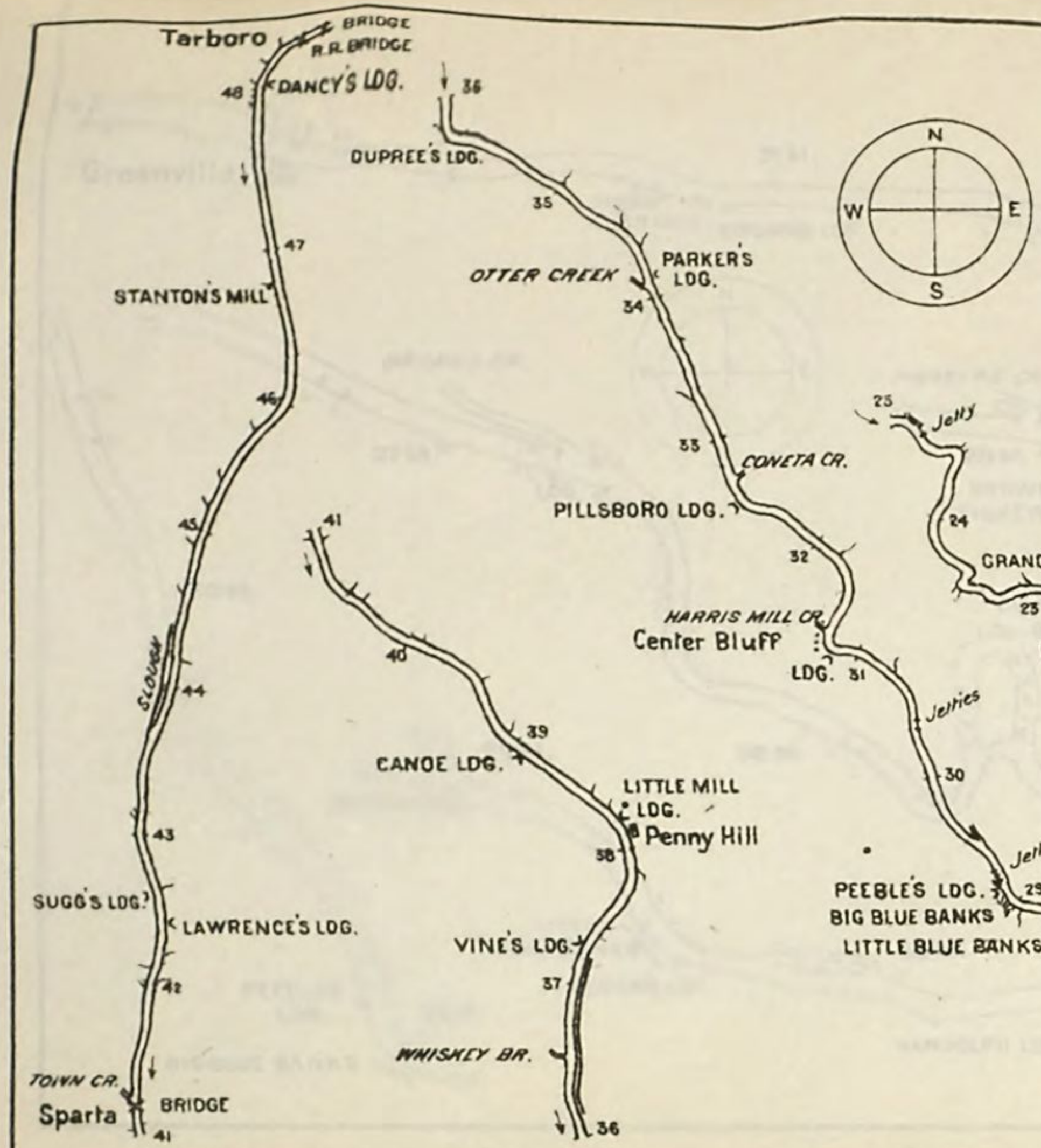
SCALE OF MILES

1 ½ 0 1 2

Original survey and map made by P. Darling in 1882
Reduced and drawn in office of Captain W. H. Bixby, Corps of Engrs. U.S.A.
by P. Brosig, February 1890.
Surveys made under direction of Capt. J. Mercur, U.S. Engrs.

= LANDINGS FOR BOATS

Official
W. H. Bixby
Capt. Engrs

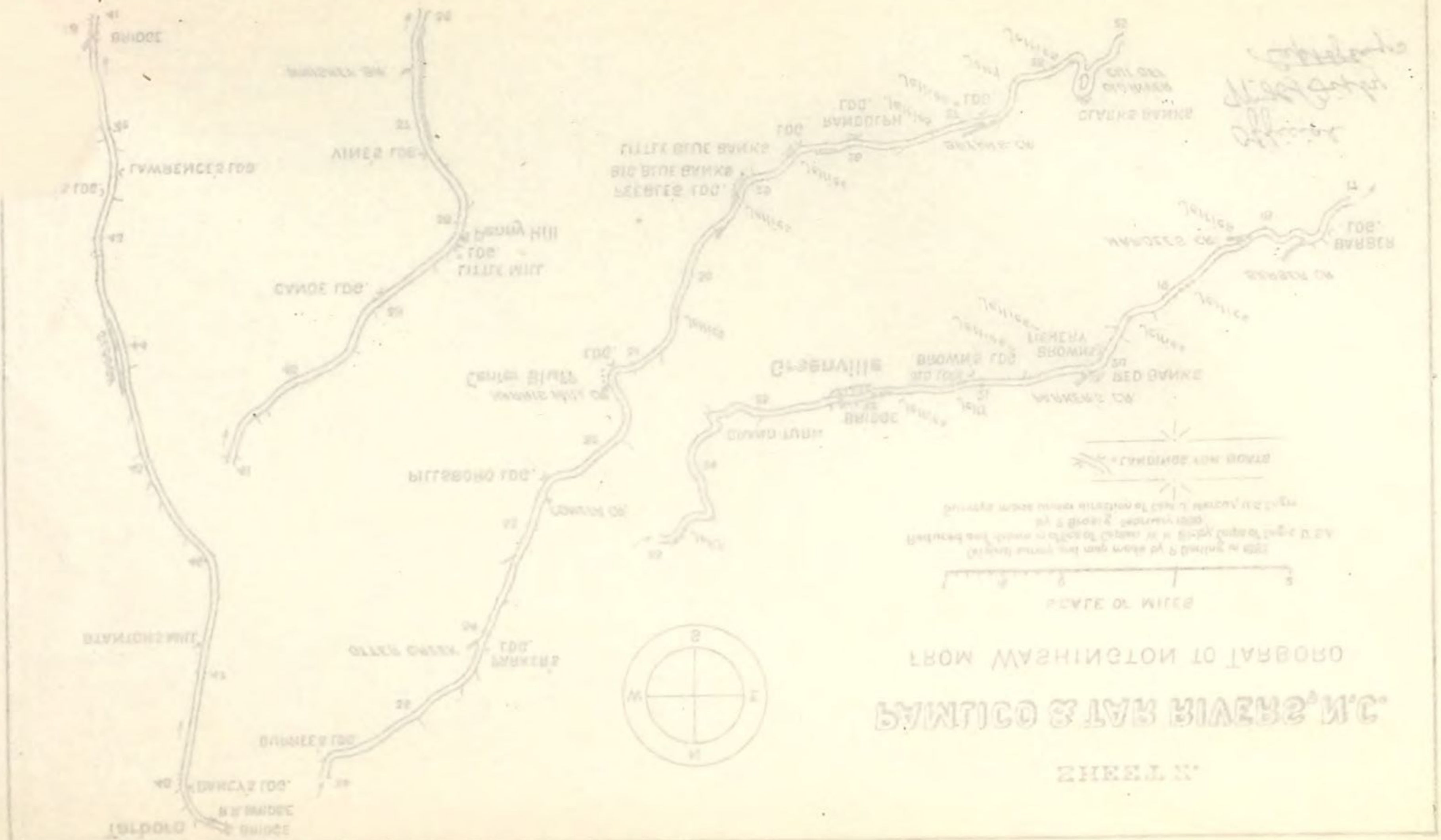


PANTICO & TAR RIVERS N.C.

FROM WASHINGTON TO TARBORO

SHEET N.

SCALE OF MILES



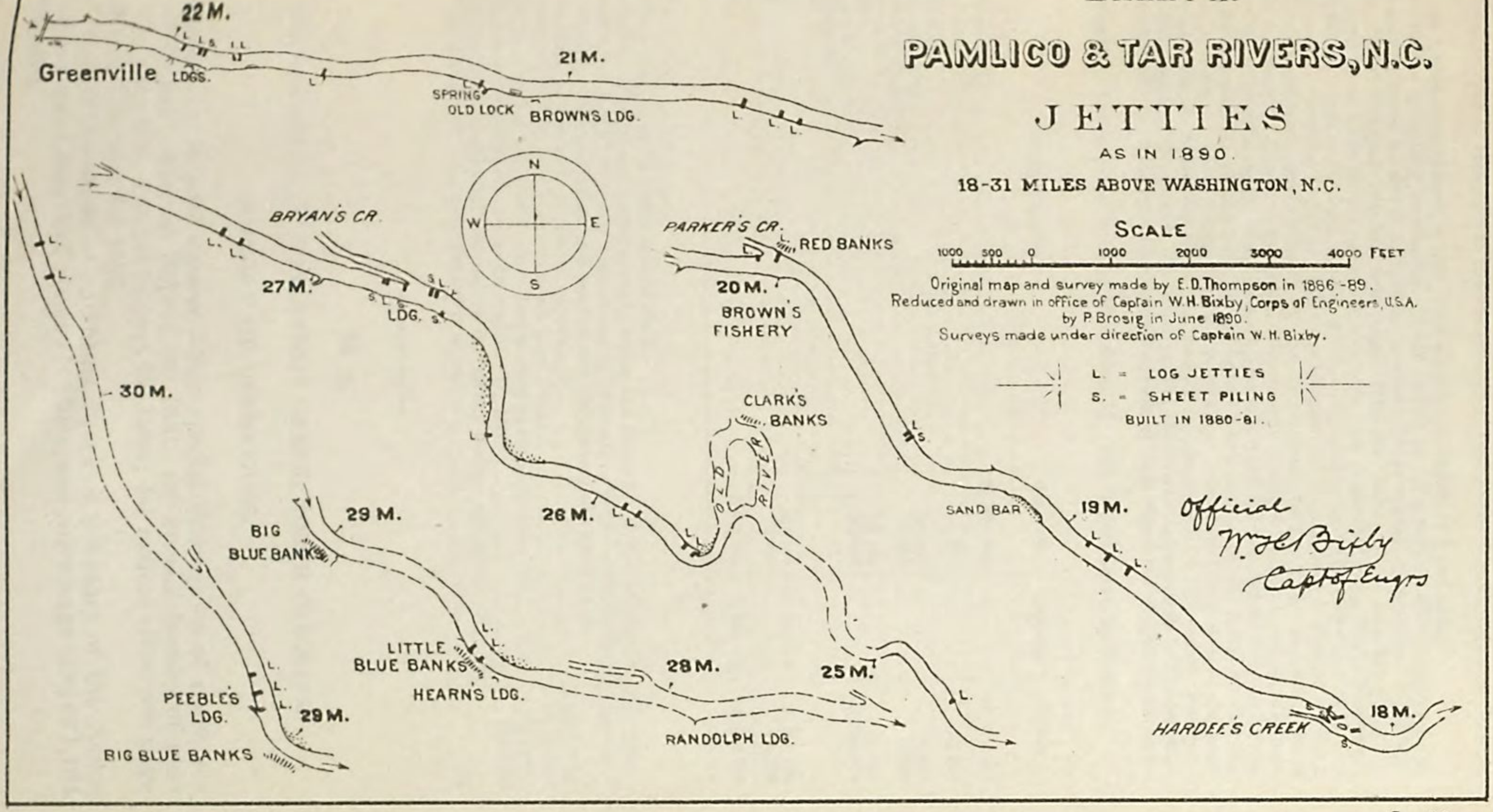
SHEET 3.

PAMLICO & TAR RIVERS, N.C.

JETTIES

AS IN 1890.

18-31 MILES ABOVE WASHINGTON, N.C.



SCALE

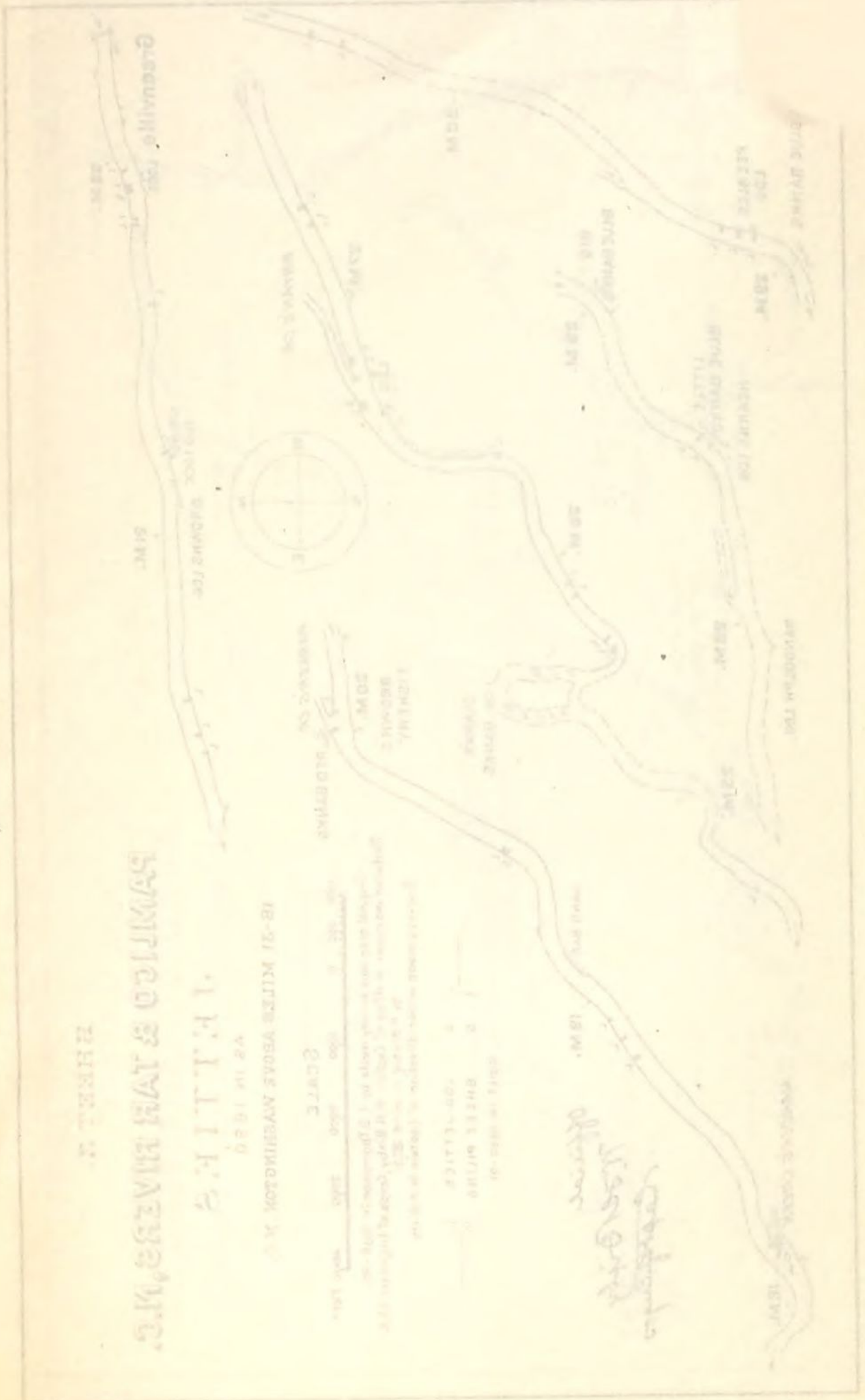
1000 500 0 1000 2000 3000 4000 FEET

Original map and survey made by E. D. Thompson in 1886-89.
Reduced and drawn in office of Captain W. H. Bixby, Corps of Engineers, U.S.A.
by P. Brosig in June 1890.
Surveys made under direction of Captain W. H. Bixby.

L. = LOG JETTIES
S. = SHEET PILING
BUILT IN 1880-81.

Official
W. H. Bixby
Capt of Engrs

Eng 90



The present rates of freight are estimated to be from 12 to 50 per cent. less than in 1876.

The river marine insurance is now only about one-tenth of 1 per cent.

The commerce is rapidly increasing. Each dollar so far spent on this improvement has been accompanied by the development of about $64 of annual commerce. Washington, N. C., has developed rapidly, and since 1882 the value of its taxable property has increased more than 25 per cent. Greenville had increased from 912 inhabitants and $266,000 real estate in 1880, up to 2,500 inhabitants and $600,000 real estate in 1886, and is still growing rapidly. The development of these towns is almost entirely due to the Government improvement of the river since 1876. This improvement is beneficial not only in this neighborhood, but to the country at large, since the lumber and cotton brought down the river are sent all over the United States, and even to many foreign countries, whence by exchange they return in the form of ice, dry goods, meat, flour, farming tools, etc., an exchange almost entirely due to the lessened freight charges resulting from the recent improvement of the water transportation of this particular stream. It is estimated that the continuation of the present improvement will be followed by a continuation of this rapid development of commerce.

The commerce for the year ending December 31, 1889, is estimated as follows:

Class of goods.	Exports.	Imports.	Totals.
Cotton and products	$1,016,500	.....	$1,016,500
Tobacco	.....	.....	.....
Rice	3,855	.....	3,855
Grains and forage	.....	.....	.....
Vegetables and truck	20,955	.....	20,955
Live stock and products	8,000	.....	8,000
Fish, oysters, etc	.....	.....	.....
Naval stores	15,000	.....	15,000
Lumber and products	1,300,000	.....	1,300,000
Coal and minerals	.....	.....	.....
Fertilizers	.....	.....	.....
Machinery	.....	.....	.....
General merchandise	104,000	$2,200,000	2,304,000
Sundries	2,500	.....	2,500
Total	2,470,810	2,200,000	4,670,810

Total tonnage, 178,720 tons.

No new transportation lines established.

The above statistics are based mainly upon the reports of Superintendent R. Ransom, made after much correspondence and conversation with steam-boat captains and agents, custom-house officials and prominent shippers and merchants.

The commerce at present, as above shown, is	$4,670,810
The commerce before the improvement began was	500,000
The development of commerce since beginning of improvement is	4,170,810
Expended on improvement up to December 31, 1889	65,098
The development of annual commerce for every dollar spent on the improvement since its commencement is about	64

M 3.

IMPROVEMENT OF CONTENTNIA CREEK, NORTH CAROLINA.

HISTORY OF OPERATIONS.

(1) *References to past reports.*—For special description of river, see pages 1010–1012, Annual Report for 1881; for special history of past work, see page 975, Annual Report for 1886; for map of river, see page 1014, Annual Report for 1887.

(2) *Original condition.*—Contentnia Creek, a tributary of the Neuse River, has a total length of about 144 miles, and a drainage area of 1,184 square miles.

When placed under Governmental improvement in 1881, this stream had a depth of about 3 feet during nine months of the year, from its mouth in the Neuse upward about 63 miles to Stantonsburg, its practical limit of navigation; but its channel was completely blocked at all stages of water by sunken logs and stumps and by floating obstructions. Its steam-boat commerce was then nothing.

(3) *Plan of improvement.*—The original project of 1881, as continued to date, proposed to secure a safe and unobstructed 3-foot navigation over this entire distance during the high-water season of about nine months. A personal examination of the river over its entire length in 1884–'85 revealed the agricultural richness of the river basin, its urgent need for better transportation facilities, and the worthiness of the improvement.

The total final cost of this work was estimated in 1888 to be $77,500.

The aggregate amount appropriated for this project up to June 30, 1890, is $45,000.

The funds now on hand will be used up before new appropriations can become available.

(4) *Results.*—Up to 30th June, 1889, a total of $43,378.02 had been spent in all upon this improvement in securing a moderately well cleared 3-foot navigation over the 31 miles from its mouth up to Snow Hill, and a very roughly cleared 3-foot navigation over the remaining 32 miles to Stantonsburg during the high-water season.

In consequence of this, two steam-boats had made trips twice a week up to Snow Hill during nearly nine months each year, the river above Snow Hill was fairly navigable for steamers of 3-foot draught for eight or nine months of the year, and flats also plied between Snow Hill and Stantonsburg, to the great benefit of the neighboring country, otherwise without transportation facilities for its products. The work above Snow Hill, though of very recent date, had already produced good results. The commerce (including rafted goods) was rapidly increasing, and was then above $1,000,000 of goods transported per year, showing that each dollar once spent on the improvement has been accompanied by the development of more than $20 in annual commerce.

The navigation of this river was not obstructed by bridges without draws.

(5) *Work of the past year.*—The special work of the past year is as follows: Expenditures, $550.50; value of United States plant, $2,[illegible]80.

On account of the near exhaustion of funds all active operations were suspended January 20, 1889. Work during the fiscal year has been restricted mainly to office duties and minor work.

A small reserve has been retained for special snagging and emergencies.

Water-gauges have been kept at three places during the year.

Inspection of property and work have been made during the year.

This improvement has been under the immediate supervision of Superintendent R. Ransom, whose report is herewith appended.

As there has been no active work done during the past year, the steam-boat navigation is much obstructed by snags and sunken logs. The commerce has steadily increased, and it is believed that there will be a still larger increase when the river is thoroughly cleared. Otherwise, the situation remains about the same as at the beginning of the fiscal year.

The latest reliable commercial statistics, those for the year ending December 31, 1889, are herewith appended, showing a commerce of $1,219,000 per year, about 63,250 tons.

(6) *Recommendations for future work.*—It is recommended that this improvement be completed in accordance with the present proposed and approved project, so as to secure a thoroughly cleared 3-foot navigation over the entire river from its mouth upward to Stantonsburg during the nine commercial busy months of the year, at a total expense of $32,500 in addition to the funds available June 30, 1890, this amount to be appropriated in yearly installments of as much as $30,000 until complete. smaller appropriations may increase the cost by from $1,000 to $4,000 per appropriation. Further improvement, so as to extend this navigation above Stantonsburg, or so as to make any part of the river navigable during the low-water season, is not recommended at present.

After the improvement is finished its proper maintenance may cost from $1,000 to $3,000 per year.

This river is in the second collection district of North Carolina.

Money statement.

July 1, 1889, amount available		$1,621.98
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$497.00	
July 1, 1890, liabilities outstanding	53.50	
		550.50
July 1, 1890, balance available		1,071.48
Amount appropriated by act of September 19, 1890		7,000.00
Amount available for fiscal year ending June 30, 1891		8,071.48
Amount (estimated) required for completion of existing project		25,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		25,500.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

REPORT OF MR. R. RANSOM, SUPERINTENDENT.

UNITED STATES ENGINEER OFFICE,
New Berne, N. C., June 11, 1890.

CAPTAIN: I have the honor to submit the following report of operations for the improvement of Contentnia Creek, North Carolina, for the fiscal year ending 30th of June, 1890:

At the beginning of the fiscal year $571.18 remained from what was allotted to be expended by me of the appropriation of 1888. Your orders contemplated that such amount should be expended for superintendence, the care of property, repairs, etc., and for some work upon "Spring Slough," near the mouth of the stream.

* * * * * * *

Owing to the stage of water being too high, it has been deemed best not to attempt any work upon "Spring Slough." Should the best stage be reached the small sum remaining will be expended upon the necessary work in "Spring Slough."

Last season was a trying one for the agriculturists of this region, the excessive rains causing very great injury to the crops. The timber business, however, was much extended, and the export tonnage materially increased. * * *

The recommendations made and repeated in former reports are repeated here. Thirty thousand dollars may be advantageously expended during the ensuing year upon this stream in execution of the project adopted for its improvement. With the very small appropriations at our disposal everything done is accomplished under great disadvantages as to efficiency, expedition, and economy, and the operations of past years suffer correspondingly.

Very respectfully, your obedient servant,

R. RANSOM, *Superintendent.*

Capt. W. H. BIXBY,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

When work commenced in 1881 the steam-boat commerce was nothing, its rafting commerce was insignificant, and the products of the neighborhood had to be hauled overland long distances to market.

At present four steam-boats (with an aggregate tonnage of 219 tons and carrying capacity of 600 bales of cotton) enter this river; of these boats, two stop near the mouth and two run 31 miles up the river to Snow Hill during nearly nine months of the year, carrying over $1,200,000 of goods per year.

The present rates of transportation are estimated to be nearly 50 per cent. less than those of 1881.

The river-marine insurance is now only one-tenth of 1 per cent., in contrast to one-eighth of 1 per cent. in 1886, and no fixed rate prior to that time.

The commerce is rapidly increasing. Each dollar so far spent on this improvement has been accompanied by the development of $28 of annual commerce. Bell's Ferry, 4 miles from the river mouth, which in 1880 possessed only 1 store, a few houses, and 37 inhabitants, had increased in 1886 up to 37 stores and houses, several churches, mills, and school-houses, with about 200 inhabitants, and a commerce of about $200,000. Snow Hill, 31 miles from the river mouth, had in the same interval increased from 332 inhabitants up to 500 inhabitants. In both towns property had increased in like proportions. It is estimated that the increase for the last year has been at fully as great a ratio, and that this development will continue with the improvement of the river. The benefit of the improvement above Snow Hill is already markedly perceptible. There is in this river basin an exceptionally heavy growth of heavy and valuable timber (pine trees of 6 and 7 feet diameter, oak and gum, yielding sticks 2 feet square and 60 feet long, ash, cypress, maple, and walnut of useful size), which now has a market open to it, which has heretofore been unsalable for lack of transportation. In 1888 41,000,000 feet of lumber was taken out above Snow Hill as against nothing the preceding year, although the river was not open for even rafting until late in the year.

This improvement is beneficial not only to this neighborhood, but to the whole country, since the cotton, timber, and other products are sent to the North and West of the United States, whence by exchange they return in the form of dry goods, hardware, flour, meats, etc., an exchange due almost entirely to the lessened freights resulting from the recent improvement of the water transportation of this particular stream. For example, in 1887, for the first time, the farmers were able to get ice by water from Maine; hay and flour in large quantities by water from the Western States *via* New York; furniture and fertilizers from South Carolina.

The commerce for the year ending December 31, 1889, is estimated as follows:

Class of goods.	Exports.	Imports.	Total.
Cotton and products	$370,000	.....	$370,000
Rice	4,500	.....	4,500
Vegetables and truck	18,650	.....	18,650
Live stock and products	9,200	.....	9,200
Naval stores	3,000	.....	3,000
Lumber and products	169,000	.....	169,000
General merchandise	45,000	$600,000	645,000
Total	619,350	600,000	1,219,350

Total tonnage, 63,250 tons.
No new transportation lines established.

The above statistics are based mainly upon the reports of Superintendent R. Ransom, made after much correspondence and conversation with steam-boat captains and agents, custom-house officials, and prominent shippers and merchants.

The commerce at present, as above shown, is (63,250 tons)	$1,219,350
The development of commerce since beginning of improvement is	1,219,350
Expended on improvement up to December 31, 1889	43,491
The development of annual commerce for every dollar spent on the improvement is	28

SHEET 1.

CONTENTNIA RIVER, N.C.

FROM MOUTH OF RIVER TO STANTONSBURG

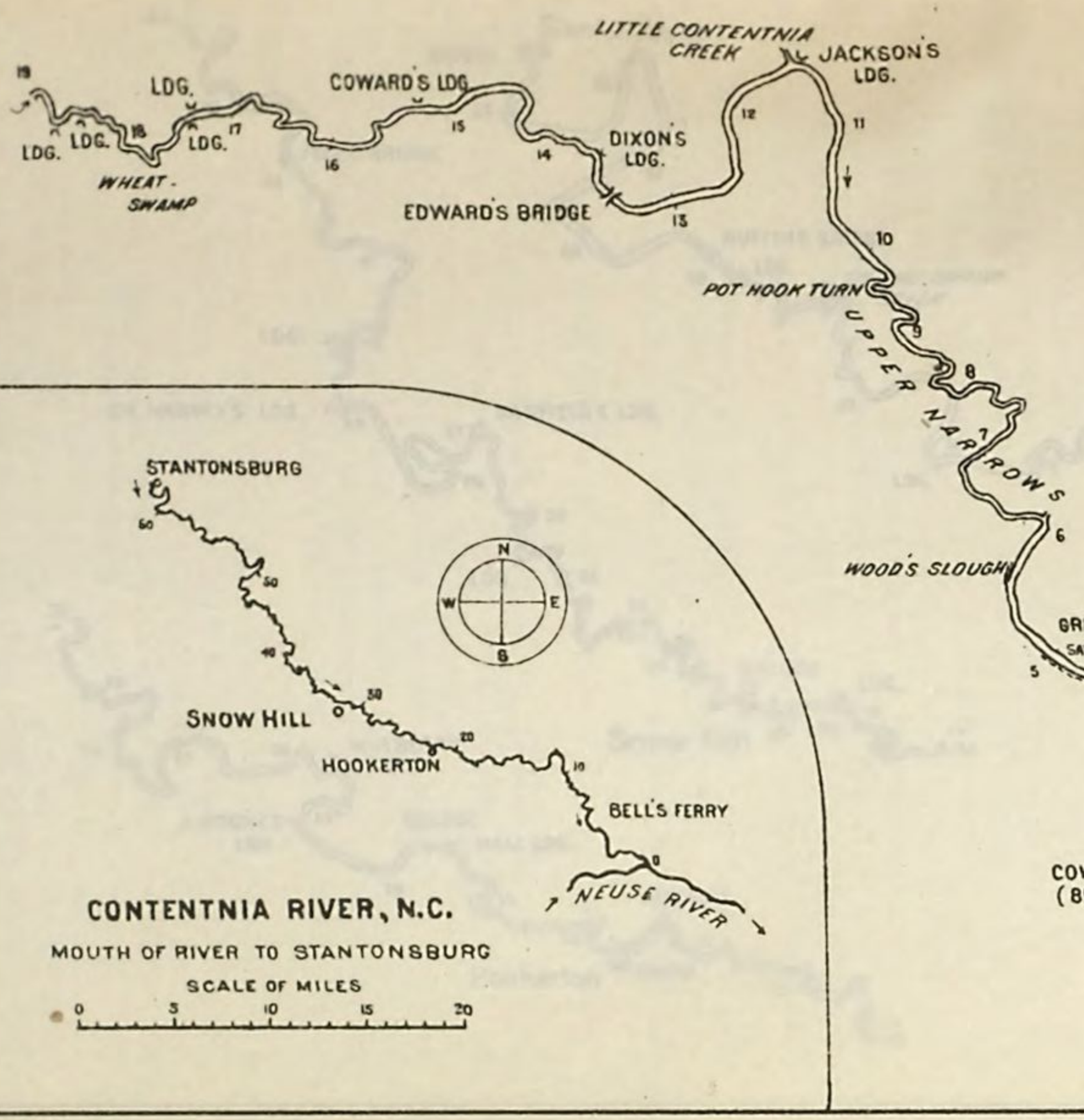
SCALE OF MILES

1. 0.5 0 1 2

Original maps and surveys made by R. Whitford 1881 & A.K. Shepard 1885
Reduced in office of Captain W.H. Bixby, Corps of Engineers, U.S.A.
by P. Brosig in March 1890.
Surveys made under direction of Capt. C.B. Phillips, U.S. Engrs.

Official
W. H. Bixby
Capt. Engrs

LANDINGS FOR BOATS.

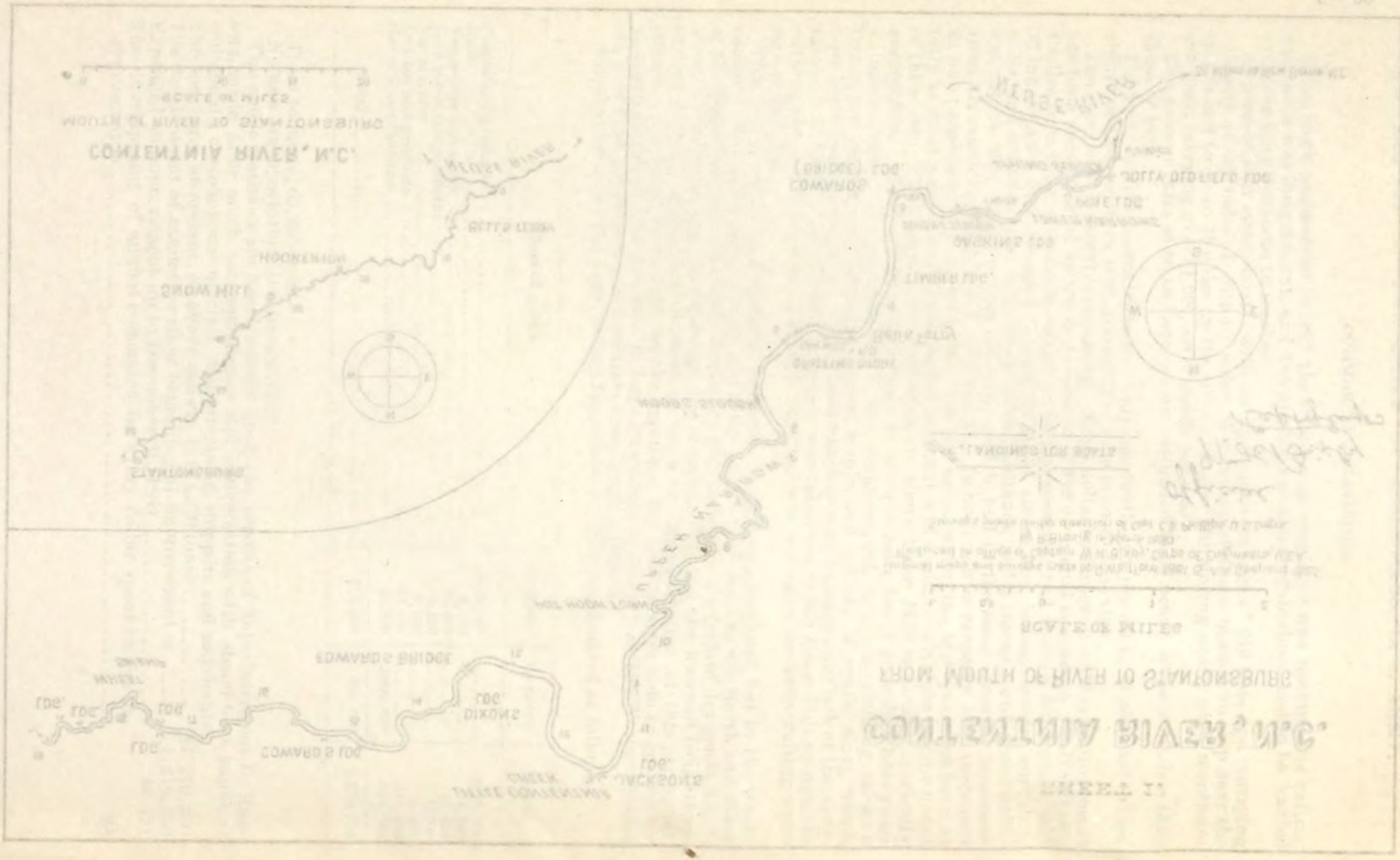


CONTENTNIA RIVER, N.C.

MOUTH OF RIVER TO STANTONSBURG

SCALE OF MILES

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CONTENTNIA RIVER, N.C.
FROM MOUTH OF RIVER TO STANTONSBURG
SCALE OF MILES
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STANTONSBURG
SNOW HILL
HOOKERTON
BELLA CASA
MERRITT MINES
EDWARDS BRIDGE
COMFORT
TAYLOR'S CONVENIENCE
DIXONS
MAYETT
TAR HOPE LOCK
TAR HOPE LOCK
TAR HOPE LOCK

SHEET 2.

CONTENTNIA RIVER, N.C.

FROM MOUTH OF RIVER TO STANTONSBURG.

SCALE OF MILES

1 0.5 0 1 2

Original map and survey made by R. Whitford 1881
Reduced in office of Captain W.H. Bixby, Corps of Engineers, U.S.A.
by P. Brosig in March 1890.
Surveys made under direction of Capt. C.B. Phillips, U.S. Engrs.

= LANDINGS FOR BOATS

Stantonsburg
BRIDGE
FOOLS BRIDGE
RUFFIN'S BRIDGE
LDG.
TOISNOT SWAMP CREEK
LDG.
DR. HARVEY'S LDG.
BARFIELD'S LDG.
LDG.
LDG.
BRIDGE
LDG.
LDG.
Snow Hill
MULBERRY LDG.
J. HOOKE'S LDG.
BRIDGE
HALL LDG.
TAR LDG.
HooKerton
BRIDGE
SPEIGHTS BRIDGE

N W E S

Official
Wm. H. Bixby
Capt. Engrs

SHEET 2.

CONTENTNIA RIVER, N.C.

FROM MOUTH OF RIVER TO STANTONSBURG.

SCALE OF MILES



M 4.

IMPROVEMENT OF TRENT RIVER, NORTH CAROLINA.

HISTORY OF OPERATIONS.

(1) *References to past reports.*—For special description of river, see pages 713, 714, Annual Report for 1879, and pages 1140–2 for 1889; for special history of past work, see page 978, Annual Report of 1886. For maps of river see page 1054, Report of Chief of Engineers for 1889.

(2) *Original condition.*—Trent River, a tributary of the Neuse River, has a total length of about 73 miles and a drainage area of 657 square miles.

When placed under governmental improvement in 1879 this stream possessed a 6-foot to 8-foot roughly cleared navigation from its mouth at New Berne up, 18 miles, to Pollocksville, and a lighter-draught navigation 7 miles farther to Quaker Bridge. Above Pollocksville the bars, snags, and trees prevented all navigation, except occasionally by small flat-boats during high freshets. Its commerce is now estimated to have then been about $400,000 of goods per year.

(3.) *Plan of improvement.*—The original projects of 1879 to 1889, as continued to date, assumed that 6 to 8 feet of water could be carried at all stages 18 miles to Pollocksville, and proposed to secure a thoroughly-cleared 3-foot navigation, with at least 50 feet channel width, at all stages of water from Pollocksville, 20 miles up, to Trenton, and at least 30 feet channel width and over 3 feet depth during winter stages of water from Trenton, 30 miles up, to the Narrows above Free Bridge, and a good channel for pole-boats 13 miles farther to Upper Quaker Bridge.

A personal examination of the river over its entire engtth in 1884, 1885, and 1889 revealed the agricultural richness of the river basin, its need of better transportation facilities, and the worthiness of the improvement.

The total final cost of this work was estimated in 1899 to be $59,000 below Trenton and $13,000 above Trenton, total $72,000.

The aggregate amount appropriated for this project up to June 30, 1890, is $50,500.

The funds now on hand will be exhausted before new appropriations can become available.

(4) *Results.*—Up to June 30, 1889, a total of $49,572.38 had been spent in all upon this improvement in securing a well-cleared channel 10 to 12 feet deep at all stages (12 to 14 feet deep at ordinary stages) from New Berne, 18 miles up, to Pollocksville, thence a channel 6 to 8 feet deep at all stages (8 to 9 feet deep at ordinary stages) 7 miles farther to Quaker Bridge, thence a well-cleared channel 50 feet wide and 3 feet deep at all stages 15 miles farther to Trenton, and a good turning basin at Trenton.

An inspection of this turning-basin showed considerable shoaling, due to the town allowing the surface drainage to run into the basin and permitting private individuals to roll logs down the side revetments of the basin. In consequence of this improvement steam-boat navigation has been established over the entire river to Trenton, making trips weekly in summer and three times a week in the busy winter season.

The commerce was steadily increasing, and was then about $900,000 worth of goods transported per year, showing that every dollar once spent on this improvement has been accompanied by the development of about $10 of annual commerce.

The navigation of the river was not obstructed by bridges without draws.

(5) *Work of the past year.*—The special work of the past year is as follows: Expenditures $807.03; value of United States plant $110.

Owing to the near exhaustion of funds, all active operations were suspended in May, 1889, and during the past year work has been confined to office duties and minor work.

Minor surveys have been made from time to time as a check on the results of past work and to prepare for future work.

In May, 1890, Assistant Engineer Charles Humphreys, with the steam-launch *H. G. Wright*, made a trip over the entire navigable portion of the river, establishing mile-posts and marking the location of all jetties for future reference.

Water-gauges were kept at three places on the river.

Inspections of work and property were made during the year.

The improvement has been under the immediate supervision of Superintendent R. Ransom, whose report is herewith appended.

As no field work has been done during the past year, the condition of the river remains about the same as at the beginning of the fiscal year.

The stream is much obstructed by snags and sunken logs which constantly obstruct the steam-boat navigation.

The latest reliable commercial statistics, those for the year ending December 31, 1889, are herewith appended showing a commerce of $958,850 per year, about 98,130 tons.

(6) *Recommendations for future work.*—It is recommended that the present approved and adopted project be completed by thoroughly clearing the channel of its remaining obstructions from the mouth of the river up to Trenton, and that the portion of the river from Trenton to the Upper Quaker Bridge be opened for navigation by removing the overhanging trees from the banks and the snags and like obstructions from the channel, at a total final cost of $21,500 in addition to the funds available June 30, 1890.

This amount should be appropriated in sums of about $10,000 per year. Smaller appropriations may increase the cost by about $2,000 per appropriation.

After the improvement is finished the proper maintenance of the improved channel may cost from $1,000 to $2,000 per year.

This river is in the collection district of Pamlico, N. C.

Money statement..

July 1, 1889, amount available		$927.62
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$752.50	
July 1, 1890, outstanding liabilities	54.53	
		807.03
July 1, 1890, balance available		120.59
Amount appropriated by act of September 19, 1890		5,000.00
Amount available for fiscal year ending June 30,1891		5,120.59
Amount (estimated) required for completion of existing project		16,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		10,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. R. RANSOM, SUPERINTENDENT.

UNITED STATES ENGINEER OFFICE,
New Berne, May 20, 1890.

CAPTAIN: I have the honor to submit below annual report of operations for the improvement of Trent River, North Carolina, during the fiscal year which ends June 30, 1890.

Excepting a preliminary survey made by you last August, in which I accompanied you, no operations have been conducted for the want of funds.

* * * * * * *

There has been a marked increase in the lumber trade, and if the upper river can be opened in accordance with your recommendations the tonnage will probably double in twelve months.

There has been little deterioration in the improvements heretofore made except in the immediate vicinity of Trenton, where sand has accumulated so as to stop the passage of steamers at moderately low stages of water from Mill Run to Trenton. Redredging and revetments will be required over this space. You know the character of the stream and its banks over this part of it too well to require any description from me.

Once a year, at least, the stream should be passed over with a hoisting machine to clear the obstructions which accumulate from natural and constantly recurring causes.

The very small amount of appropriations received in the past four years has prevented that attention to the improvement and extension of navigation which the demands of commerce and the dictates of good economy reasonably expect and justify.

An appropriation of $20,000 in one sum could be expended during the next twelve months to great profit to the people along this stream, and to a large comparative increase in general commerce.

Very respectfully, your obedient servant,

R. RANSOM,
Superintendent.

Capt. W. H. BIXBY,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

When work commenced in 1879 steamers could not go more than 18 miles, up to Pollocksville. The river commerce is estimated to have then been about $400,000 of goods per year.

At present steamers make regular trips twice a week in summer and three times a week or daily in the busy season of winter, going 38 miles up the river to Trenton, carrying over $900,000 of goods per year.

The rates of present transportation are estimated at from 25 to 75 per cent. less than those of 1879, and river insurance is regarded as unnecessary, except against fire.

There was during the past year a falling off in the amount of cotton carried, due to the partial failure of the cotton crop, but, on the other hand, there has been a large increase in the lumber trade.

Each dollar so far spent upon the improvement has been accomplished by the development of about $10 of annual commerce.

It is thought that the future benefit will be in proportion to the past. Half the river basin is without railroad facilities, and must depend upon the river for transportation.

No detailed statement of the river commerce could be obtained from the steam-boat captains or owners.

The commerce for the year ending December 31, 1889, is estimated as follows:

Class of goods.	Exports.	Imports.	Total.
Cotton and products	$128,200	.....	$128,200
Vegetables and truck	5,400	.....	5,400
Live stock and products	9,250	.....	9,250
Fish, oysters, etc	4,000	.....	4,000
Naval stores	1,000	.....	1,000
Lumber and products	361,000	.....	361,000
General merchandise	.....	$450,000	450,000
Total	508,850	450,000	958,850

Total tonnage, 98,136 tons.
No new transportation lines established.
The above statistics are based mainly upon the reports of Superintendent R. Ransom, made after much correspondence and conversation with steam-boat captains and agents, custom-house officials, and prominent shippers and merchants.

The commerce at present, as above shown, is (98,136 tons)	$958,850
The commerce before the improvement began was	400,000
The development of commerce since beginning of improvement is	558,850
Expended on improvement up to December 31, 1889	49,752
The development of annual commerce for every dollar spent on the improvement is about	10

M 5.

IMPROVEMENT OF NEUSE RIVER, NORTH CAROLINA.

HISTORY OF OPERATIONS.

(1) *References to past reports.*—For special description of river, see pages 735–741, Annual Report for 1872; for special history of past work, see page 982, Annual Report for 1886; for map of river, see page 1058, Report of Chief of Engineers for 1889.

(2) *Original condition.*—The Neuse River, entering into the Pamlico Sound, has a total length of about 360 miles and a drainage area of 5,781 square miles (2,506 of which are situated above the mouth of its upper main tributary, the Contentnia).

When placed under governmental improvement, in 1878, this stream possessed during nine months of the year a 9-foot depth of channel from its mouth 40 miles up to New Berne, thence a 4-foot depth 50 miles further to Kinston, thence a 3-foot depth 45 miles further to Goldsborough, and thence a 2-foot depth 55 miles further to Smithfield, this channel depth being reduced during the low-water season to 8 feet at New Berne, 2 feet at Kinston, and 1 foot at Smithfield. Over the whole 198 miles the river was so blocked by war and other obstructions that navigation was impracticable. Its steam-boat navigation is now estimated to have then been only about $80,000.

(3) *Plan of improvement.*—The original projects of 1871 for below Goldsborough, and of 1879 for above Goldsborough, contemplated the removal of the war blockades and natural obstructions and the excavation of a few cut-offs so as to get 4½ feet at low water all the year to Goldsborough and 3 feet during nine months to Smithfield. The projects of 1878, 1880, and 1883, as continued to date, proposed to remove all sunken logs, snags, floating and other obstructions, and to contract the channel-way by jetties so as to assure during the entire year an unobstructed 8-foot navigation 40 miles up to New Berne, and a similar 4-foot navigation 50 miles further to Kinston, and during nine months of the year a 3-foot navigation 100 miles further to Smithfield. A personal examination of the river in 1884 revealed the agricultural richness of the river basin, its need of free transportation facilities, and the worthiness of the improvement.

The total final cost of this improvement was in 1888 estimated at $374,000.

The aggregate amount appropriated for these projects up to June 30, 1890, is $247,500.

The funds now on hand will be used up before new appropriations can become available.

(4) *Results.*—Up to June 30, 1889, a total of $233,267.77 had been spent in all upon this improvement, giving a moderately well-cleared channel over the entire length of the river, allowing an 8-foot navigation 40 miles to New Berne, and a 3-foot navigation 50 miles further to Kinston, all the year; also a fair 3-foot navigation 45 miles further to Goldsborough, during nine months per year, and thence 55 miles further to Smithfield, six months per year.

In consequence of this, six steam-boat lines had been permanently established between New Berne and Kinston, and the river commerce had increased from almost nothing up to over $5,000,000 of goods transported per year, showing that each dollar once spent on this improvement has been accompanied by the development of about $20 of annual commerce.

The navigation of this river was obstructed at points as follows:

Near Kinston this river was crossed by the Atlantic and North Carolina Railroad on a draw-bridge, whose draw-span is placed upon the shallow side of the river instead of over the main channel-way. The present improvement will probably be so far finished in 1892 as to permit of a deeper navigation above this bridge at Kinston than will then be able to pass through this draw-opening. All the steamer captains, so far heard from, state that they have not as yet been delayed from want of water at this draw-opening, and there appears no special reason for a change in the position of the draw before 1892. It was recommended that this draw be permitted to remain in its present position for the present, but that it be moved to the channel side of the river as soon as it becomes the chief serious obstruction to a permanently increased depth of navigation between New Berne and Kinston.

Near Goldsborough this river was crossed by the Wilmington and Weldon Railroad on a single-span bridge without a draw. The bottom of the bridge was about 17 feet above low water. The channel was said to be partially obstructed by a pier of the former bridge. Very few steamers had so far reached this bridge, although the river was navigable for several miles above Goldsborough. It is recommended that this bridge be permitted for the present to remain in its present condition, the owners in due time to clear away the obstructing portion to the old pier beneath, and to furnish a suitable hinge-joint to the smoke-stacks of all steamers using regularly this portion of the river.

Above Goldsborough and below Smithfield there were six county bridges without draws; but there had as yet been no navigation demanding draws. When needed, the draws will undoubtedly be put in by the county authorities. It was recommended that these bridges be permitted for the present to remain in their present condition, their owners to insert draws therein whenever needed by the steamers.

(5) *Work of past year.*—The special work of the past year is as follows: Expenditures, $12,230.66; value of United States plant, $3,825.

During the working season four steam hoisters and other plant were in use on the river.

Owing to its variable features and the difficulty of properly specifying it beforehand and measuring it afterwards, all work was, for advantage and economy, allowably done by hired labor and the purchase of materials in open market.

From July 1 to 13 the plant was on its way to the Wilmington and Weldon Railroad bridge at Goldsborough (about 95 miles above New Berne), reaching the bridge on the latter date.

Between July 14 and October 31, from 95 miles of the river between

New Berne and the Goldsborough Railroad Bridge, there were removed as follows: From the channel 309 logs, 280 stumps, 435 trees, 607 large snags, 15 cords of small snags, 295 linear feet of old jetty, and 28 old piles; from the banks: 2,051 trees cut and pulled back, 100 trees trimmed, 533 cords of brush cut, 112 logs rolled back, 410 large stumps hoisted and blasted, and 336 cubic yards of banks excavated; in the river 1 guide-pile was driven.

During October, at Spicer's Lane Landing (19 miles above New Berne), a ditch 200 feet long, 15 feet wide, about 3 feet deep, was cut across a projecting point of bank, preparatory to the removal of this point at some future date. Owing to the commencement of the winter high-water season all further active operations in the field were stopped on October 31, and the plant was laid up for the winter, to await a more favorable stage of water.

The stage of water being favorable, active operations were resumed June 7 and continued during the month.

From June 7 to June 30 work of jettying was pushed as rapidly as possible, and this work is still in progress.

Two thousand and twenty-one linear feet of sheet-pile jetties were built in place, 282 linear feet of old jetties were removed, 2 guide-piles were driven, 26 mats made and sunk, 4 logs, 1 stump, and 6 large snags were removed from the channel.

In May and June Assistant Engineer Chas. Humphreys, in the steam-launch *H. G. Wright*, went over the entire navigable portion of the river, establishing mile-posts, marking the location and length of all jetties for future reference, and making surveys of various shoals in the river.

Three water-gauges were kept during the year.

Inspections of work and property were made during the year.

The improvement has been well carried on under the immediate supervision of Superintendent R. Ransom, whose report is herewith appended.

The work of the past year has much improved the existing fair navigable condition of the river over the 95 miles between New Berne and the Goldsborough Railroad Bridge. The river is well cleared to its natural widths and depths. The commerce of the river is steadily increasing, otherwise the situation remains about the same as at the beginning of the fiscal year.

The latest reliable commercial statistics, those for the year ending December 31, 1889, are herewith appended, showing a commerce of $6,467,103 per year, about 186,638 tons.

(6) *Recommendations for future work.*—It is recommended that this improvement be completed in accordance with the present approved and adopted projects, so as to secure a thoroughly-cleared 9-foot navigation up to New Berne and a similar 4-foot navigation to Kinston during the entire year, and thence a similar 3-foot navigation to Smithfield during nine months of the year, at a total expense of $126,500 in addition to the funds available June 30, 1890, this amount to be appropriated in yearly installments of as much as $60,000 each. Smaller yearly appropriations, involving the alternate disorganization and reorganization of working parties, damage to unfinished work, extra superintendence, and the deterioration of plant may increase the cost of the work by from $2,000 to $6,000 per appropriation. Further improvement, so as to extend the navigation above Smithfield, or so as to increase the depth of water or length of time of such navigation below Smithfield, is not recommended at present.

After the improvement is finished its proper maintenance may cost from $2,000 to $6,000 per year.

This river is in the collection district of Pamlico, N. C.

Money statement.

July 1, 1889, amount available		$14,232.23
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$10,155.42	
July 1, 1890, outstanding liabilities	2,075.24	
		12,230.66
July 1, 1890, balance available		2,001.57
Amount appropriated by act of September 19, 1890		20,000.00
Amount available for fiscal year ending June 30, 1891		22,001.57
Amount (estimated) required for completion of existing project		106,500.00
Amount that can be profitably expended in fiscal year ending June 30,1892		60,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

REPORT OF MR. R. RANSOM, SUPERINTENDENT.

UNITED STATES ENGINEER OFFICE,
New Berne, N. C., June 13, 1890.

CAPTAIN: I have the honor to submit the following report of operations for the improvement of Neuse River, North Carolina, for the fiscal year ending June 30, 1890:

On July 1, 1889, the plant was at Kinston. The first half of the month was employed in warping the plant up to the Wilmington and Weldon Railroad Bridge south of Goldsborough. To assist in this work a small steam-flat was hired to carry the lines, which materially lessened the cost and time. From the middle of July to the end of the first week in September the work of snagging and clearing banks from the railroad bridge down to 33 miles above Kinston (the point reached working upstream in 1888) was prosecuted. The plant was then dropped down to near the mouth of Grindle Creek, taking out on the way some bad obstacles which had either gotten into the channel during the past year, or which had come to view during that time.

It was proposed to recommence jettying near Grindle Creek, and main piles for several jetties were driven in September, but the water rose and stopped that character of work. From then to the end of October the plant and working force were occupied in snagging and clearing banks down stream from Grindle Creek to Spring Garden.

At Spicer Lane Landing some special work of clearing a sharp projecting point of land of timber and stumps and cutting a ditch across the point, with a view to using the current of the river through and around said point for its removal.

On November 1, 1889, operations were entirely suspended and the plant laid up at Biddle's landing for the winter. The stage of water remaining too high for jetty work, and your instructions requiring the remainder of the funds to be used for such purpose, operations were not resumed until the 7th instant.

The work done during the year is summarized as follows:

Above Kinston.—Channel work: 1.75 logs, 172 stumps, 317 trees, 353 large snags, and 8 cords of small snags were hoisted and removed. *Bank work:* 1,387 trees cut and pulled back, 69 trees trimmed, 342 cords of brush cut, 66 logs rolled back, and 268 stumps pulled from the banks.

Below Kinston.—Channel work: 134 logs, 108 stumps, 118 trees, 252 large snags, 6⅓ cords of small snags, 295 linear feet of old jetties, and 28 piles hoisted and removed. *Bank work:* 336 cubic yards of ditch cut, 664 trees cut and pulled back, 21 trees trimmed, 191 cords of brush cut, 46 logs rolled back, 142 stumps hoisted. Besides the above, 115 main piles for jetties were driven near Grindle Creek and 1 guide pile placed at jetty.

* * * * * * *

The stage of water being favorable, active operations were resumed June 7, 1889, and the work was vigorously prosecuted during the month.

Between stations 1045 and 1107, 2,021 linear feet of sheet-pile jetties were built in place; 282 linear feet of old jetties were removed; 4 logs, 1 stump, and 6 large snags

were removed from the channel; 2 guide-piles were driven and 26 mats were made and sunk.

* * * * * * *

The high water of the entire season prevented the accomplishment of as much work as more favorable conditions would have permitted, and caused an incompleteness in that done which is not most satisfactory.

The natural features and conditions of the stream make changes from time to time, and shoals have formed at a few points between this place and Kinston which are now under examination.

The many jetties from Kinston down to Village Creek have been broken in numerous places. These injuries have been caused in most cases by heavy rafts of logs brought down by timber-men. I respectfully call attention to the necessity for early repairs to these breaks.

The great damage to the agriculture of eastern North Carolina by the excessive rainfall of last year largely reduced the products of lands bordering on the Neuse River. There was a material increase in export tonnage, caused by the active traffic in timber and lumber.

* * * * * * *

I take the liberty to urge the propriety and wisdom of more generous appropriations with which the projects adopted for the improvement of this stream may be completed in reasonable time. In my judgment $65,000 to $75,000 can be most advantageously expended during the next fiscal year.

Very respectfully, your obedient servant,

R. RANSOM,
Superintendent.

Capt. W. H. BIXBY,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

When work commenced in 1878 all navigation above New Berne was restricted to one small steamer, which ran irregularly during the high-water season, carrying about 2,000 bales of cotton per year ($80,000). At present six steamers run regularly to Kinston, 50 miles above New Berne, and irregularly 45 miles farther to the railroad near Goldsborough, carrying about $6,000,000 of goods per year.

The rates of transportation at present are estimated to be from 25 to 70 per cent. less than in 1878. (For example, the freight on cotton is now 75 cents per bale by steamer, where formerly it was $2.75 per bale by wagon.) The rate of insurance has fallen 25 to 33 per cent., and marine insurance is now considered unnecessary above New Berne.

Each dollar so far spent upon this improvement has been accompanied by the development of about $18 of annual commerce.

The commerce for the year ending December 31, 1889, is estimated as follows:

Class of goods.	Exports.	Imports.	Total.
Cotton and products	$1,270,000	.....	$1,270,000
Rice	37,000	.....	37,000
Grains and forage	.....	$700,000	700,000
Vegetables and truck	315,000	.....	315,000
Live stock and products	22,250	1,150,000	1,172,250
Fish, oysters, etc	114,418	.....	114,418
Naval stores	48,250	.....	48,250
Lumber and products	1,242,185	.....	1,242,185
Coal and minerals	.....	30,000	30,000
Fertilizers	.....	175,000	175,000
General merchandise	249,000	1,100,000	1,349,000
Sundries	16,000	.....	16,000
Total	3,314,103	3,155,000	6,469,103

Approximate tonnage, 186,638 tons.

No new transportation lines established.

The above statistics are based mainly upon the reports of Superintendent R. Ran-

SHEET 2.

(STATIONS 885 – 1250 &c. ; 32 – 18.5 MILES ABOVE NEW BERNE.)

NEUSE RIVER, N.C.

JETTIES

SCALE

100 0 500 1000 1500 2000 FEET

Original survey and map made by R.B. Burks, 1885.
Reduced and drawn in office of Captain W.H. Bixby, Corps of Engineers by P. Brosig in 1890.
Surveys made under direction of Capt. W.H. Bixby, U.S. Engrs.

— = SHORE LINE
— · — = 3 FT. DEPTH AT LOW WATER
885 = SURVEY LINE AND STATIONS
—o— = CENTER LINE OF PROPOSED CHANNEL
= JETTIES BUILT PRIOR TO 1884
= JETTIES BUILT OR PROPOSED SINCE 1884
M. = MILES FROM NEW BERNE, N.C

Log Ldg.

Grindle Creek

Maple Cypress Ldg.

Big Contentnia Creek

Half Moon Creek

Biddle's Ldg.

Spicer Lane's Ldg.

19 M.

POINT TO BE REMOVED

Anderson's Ldg.

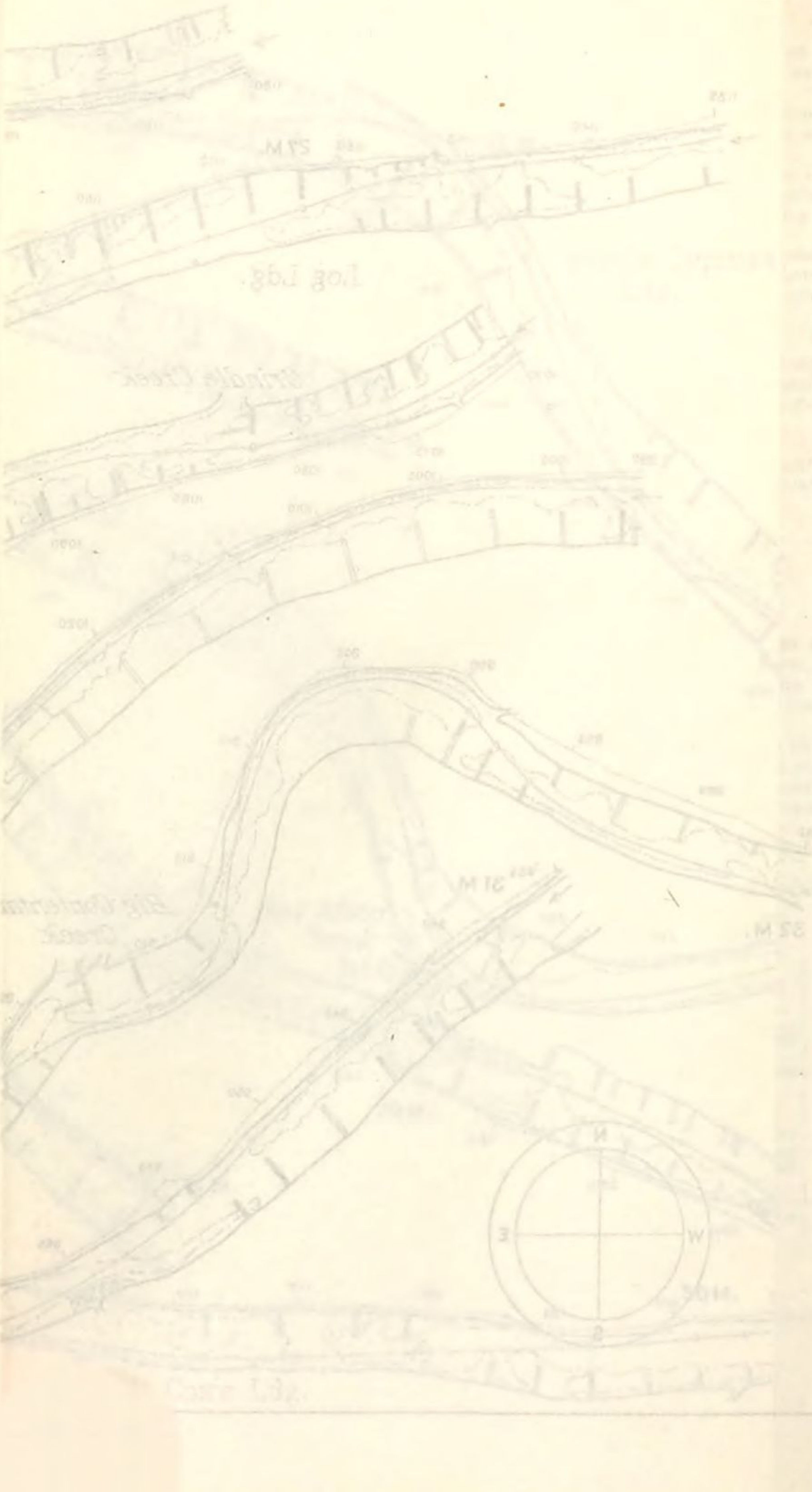
18.5 M.

Cox's Ldg.

OLD TOWN

Official
W. H. Bixby
Capt. of Engrs

Eng 90



SHEET 1.

(STATIONS 530 - 885, 39 - 32 MILES ABOVE NEW BERNE)

NEUSE RIVER, N.C.

JETTIES

SCALE

100 0 500 1000 1500 2000 FEET

Original survey and map made by R.B. Burks, 1885.
Reduced and drawn in office of Captain W.H. Bixby, Corps of Engineers by P. Brosig in 1890.

— = SHORE LINE
-·-·- = 3 FT. DEPTH AT LOW WATER
530 = SURVEY LINE AND STATIONS
—o— = CENTER LINE OF PROPOSED CHANNEL
= JETTIES BUILT PRIOR TO 1884
= JETTIES BUILT OR PROPOSED SINCE 1884
M. = MILES FROM NEW BERNE, N.C.

N W E S

Nelson's Ldg.

37 M.

38 M.

38 M.

Becton Old Field Ldg.

35 M.

Ferry

39 M.

West's Ldg

36 M.

Old Bridge

34 M.

Plank Ldg.

32 M.

33 M.

Pearce's Ldg.

ROCK BOTTOM AT 2 FT. DEPTH OF WATER PREVENTED LOCATION OF CHANNEL NEXT THE CONCAVE BANK.

Surveys made under direction of W. H. Bixby, Capt. U.S. Engrs.

Official
W. H. Bixby
Capt. Engrs.

Eng 90

PROGRESS MAP

1. JULY 1889 – 30. JUNE 1890.

NEUSE RIVER

JETTIES

27.8–29.1 MILES ABOVE NEW BERNE, N.C.

SCALE

100 0 100 200 300 400 500 FT

Based on surveys of 1885.

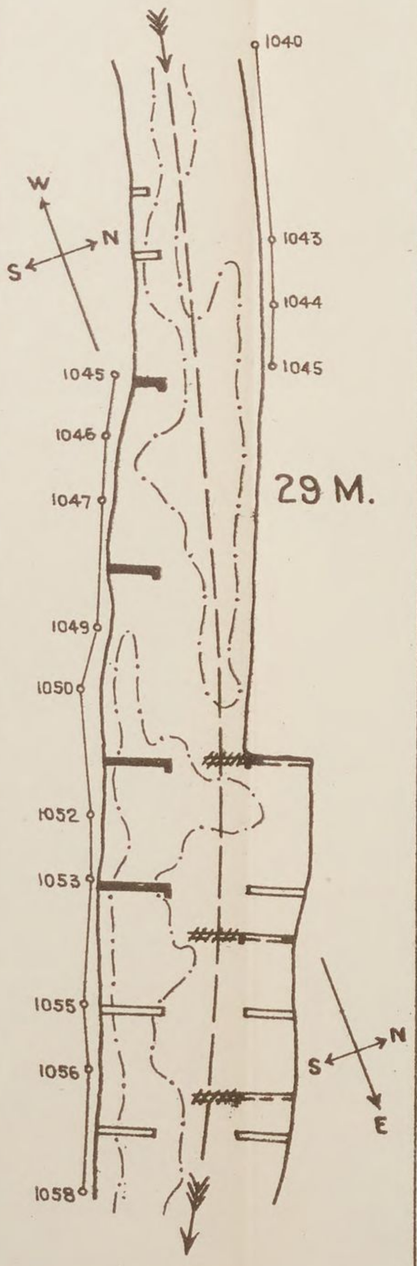
STAKED LINE OF SURVEY
RIVER BANK AT LOW WATER .
3 FT. CURVE " " "
OLD PLANK JETTIES
OLD LOG JETTIES
PROPOSED JETTIES (PLANK)
JETTIES BUILT DURING FISCAL YEAR '89/'90
" REMOVED " " " "
PROPOSED MID-THREAD OF CHANNEL

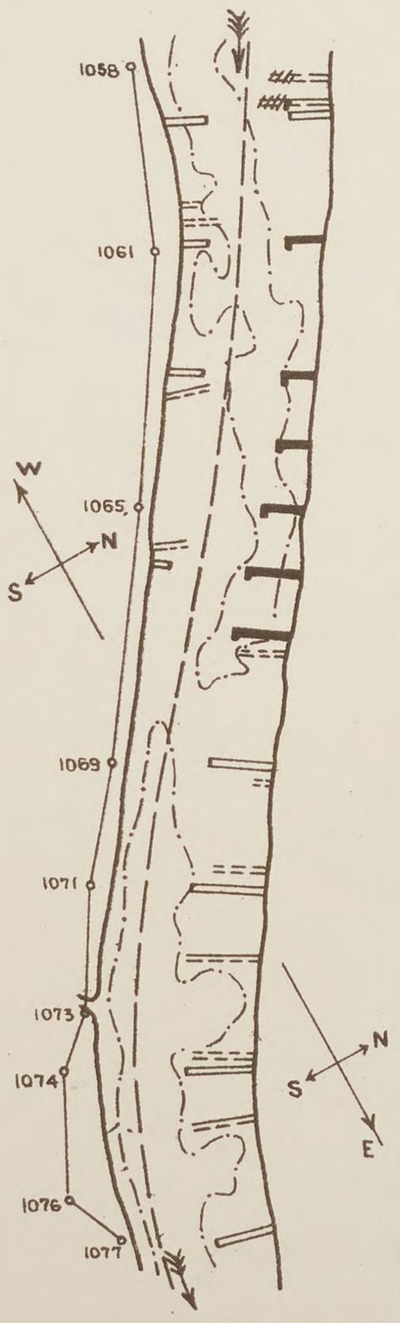
Wilmington N.C. *July 1890.*

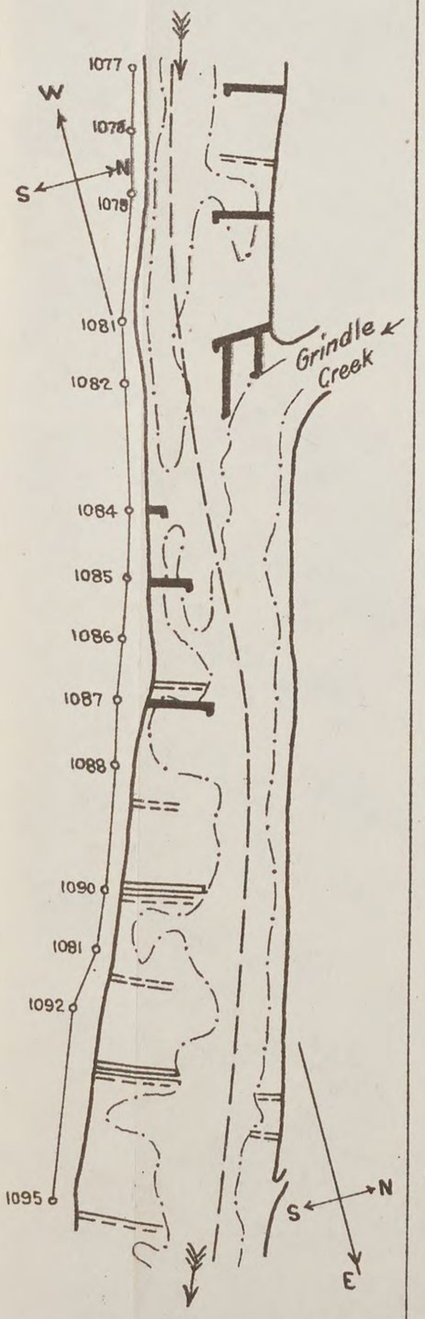
Respectfully Submitted

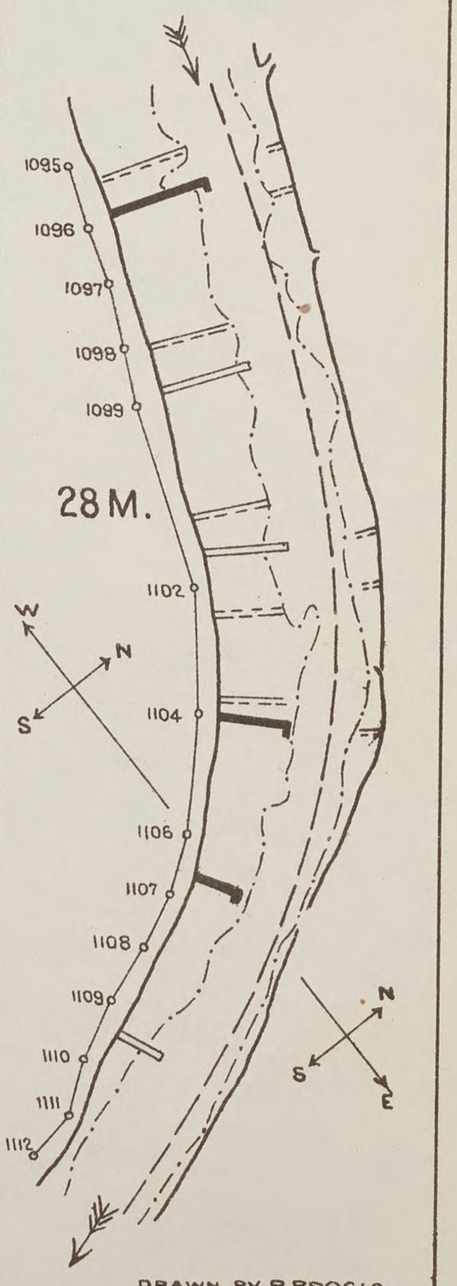
W. J. C. Bixby

CAPTAIN OF ENGINEERS









DRAWN BY P. BROSIG.

PROPOSED MID-TUNNEL OF CANAL

" REMOVED " " " "

SETTLED BUILT DURING PRESENT YEAR

PROPOSED SETTLES (PLANK)

OLD LOG SETTLES

OLD PLANK SETTLES

P.T. CURVE " "

WIVEY BANK AT LOW WATER

STAKED LINE OF SURVEY

SCALE

100 0 100 500 200 400 300 FT

52.8-SA.1 MILES ABOVE NEW BERNE RD.

SETTLES

WEAVER WORKS

JULY 1883 - 30 JUNE 1884

PROGRESS MAP



som, made after much correspondence and conversation with steam-boat captains and agents, custom-house officials, and prominent shippers and merchants.

The commerce at present, as above shown, is about 186,638 tons	$6,469,103
The commerce before the improvement began was	2,000,000
The development of commerce since beginning of improvement is	4,469,103
Expended on improvement up to December 31, 1889	241,544
The development of annual commerce for every dollar spent on the improvement since its commencement is	18

M 6.

IMPROVEMENT OF INLAND NAVIGATION AND WATER-WAY BETWEEN NEW BERNE AND BEAUFORT HARBOR, NORTH CAROLINA, VIA CLUBFOOT, HARLOWE, AND NEWPORT RIVERS.

HISTORY OF OPERATIONS.

(1) *References to past reports.*—For original estimates and description, see page 894, Annual Report for 1880; for special history of past work, see page 985, Annual Report of 1886; and for map of route, see page 1028, Annual Report of 1887; and page 1062, Annual Report of 1889.

(2) *Original condition.*—The inland line of navigation from New Berne to Beaufort Harbor via Clubfoot, Harlowe, and Newport rivers was established in about 1826, and was used thereafter by small craft until about 1856, when its locks broke down and the route was abandoned. This line, about 42 miles in total length, extends from New Berne about 23 miles down the Neuse River, 6 miles up Clubfoot River, 3.21 miles through the Clubfoot and Harlowe Canal, 3.5 miles down Harlowe River, and 6 miles through Newport River to Beaufort Harbor. About 1880 the line was re-opened by the New Berne and Beaufort Canal Company.

When placed under governmental improvement in 1885, this route allowed the passage of small boats of 15 feet width and 3-foot draught; but the commerce was then practically nothing.

(3) *Plan of improvement.*—The original project of 1883 reported this route via Clubfoot, Harlowe, and Newport rivers as worthy of improvement, providing that Congress desired to extend the already-existing lines of navigation from the Chesapeake southward; and estimated the cost of a channel 80 feet wide and 9 feet deep at $883,580, increased by the cost of a tide-lock and the canal company's franchise. A modified project of 1884 for the expenditure of the funds at that time available as continued to date, proposed to widen and deepen Harlowe Creek, so as to secure a through canal of 5 feet depth at mean low water, and of 30-foot bottom width from the mouth of Harlowe Creek upward 3.25 miles to its head, and to use the remaining funds upon similar works on Clubfoot River.

The total final cost of the latter (1884) project (including also the purchase and completion of the canal) so as to secure a channel 30 feet wide and 5 feet deep at low water from the Neuse River through to Newport River, adapted to the existing navigation of the Neuse River desiring passage by this route to Beaufort Harbor, was estimated in 1886 to be $92,000.

The aggregate amount appropriated for this project up to June 30, 1890, is $35,000.

(4) *Results.*—Up to June 30, 1889, a total of $24,242.45 had been expended in all upon this improvement, in necessary surveys, in the re-

moval of the worst logs and stumps in the existing channel, in dredging the creek for a short distance to full dimensions, and in clearing it over its entire length to a width and depth sufficient to allow the passage of small sail-boats.

In consequence of this, several hundred sail-boats had passed through the canal, and the commerce of this route had already reached about $190,000 per year, and is rapidly increasing. Rates of transportation between New Berne and Beaufort had dropped about 25 per cent, since the improvement has commenced; and each dollar once spent upon this improvement has been accompanied by the development of more than $10 of annual commerce

The navigation of this route was not obstructed by bridges without draws.

(5) *Work of the past year.*—The special work of the past year is as follows: Expenditures, $2,360.67; value of United States plant, $470.

During a portion of the year one contract dredge was at work on the improvement.

Owing to its variable features and to the difficulty of properly specifying it beforehand and measuring it afterwards, all minor work was, for advantage and enconomy, allowably done by hired labor and the purchase of materials in open market.

Dredging at the mouth of the creek was carried on under contract with the Alabama Dredging and Jetty Company, dated 25th January, 1889, for dredging to be begun July 11, 1889, and to be completed August 30, 1889.

During July one large dredge, the *Alabama*, redredged about 6,750 cubic yards of temporary dumpage and carried the same off in scows to designated dumpage ground on the shoals on the south side of the Newport River. This dredging completed the opening of a channel of 30-foot width and at least 5-foot depth at low water (with 3½-foot depth for 50-foot width) entirely across the former shoal. The contract was satisfactorily completed on the 24th of July.

The results produced by the sheet-piling built in place in the lower creek have been very satisfactory. In the latter part of July an unusually high tide and wind damaged and pulled out a portion of this piling, but during August and September this damage was repaired and 368 linear feet of the piling were replaced and banked up with oyster-shells.

In September all active operations in the field were suspended, and work has been since confined to office duties and minor work.

The funds at present available have been retained to await developments as to the proposed action of the corporation owning the New Berne and Beaufort Canal, connecting Harlowe Creek with Clubfoot Creek. Verbal statements of the former president of this canal company and of the present governor of the State of North Carolina tend to show that the canal company has in the past few years received from the State of North Carolina a present of enough money to put the canal in good navigable condition; that the present company has sought to retain this money without doing the work for which the money was granted; and that it was not willing to cede even the unfinished canal to the United States, except in return for an additional large sum of money.

A new canal, paralleling the old one, now appears from several points of view to be preferable to the old one, unless the latter is ceded to the United States free of charge.

The work of this improvement during the year has been efficiently carried on under the immediate supervision of Assistant Engineer E. D. Thompson, whose report is herewith appended.

Inspections of the property and work were made during the year.

The work of the past year on Harlowe Creek, formerly the narrowest and most dangerous part of this canal route, has completed an excellent channel for 5-feet-draught boats the entire length of Harlowe Creek, and has made the Government portion (the ends) of this route far superior to the central portion, now owned by private parties.

Many small schooners now make daily use of this route, and preparations are being made to add steam service. The commerce of the route is rapidly increasing. Otherwise the situation remains about the same as at the beginning of the fiscal year.

The latest reliable commercial statistics, those for the year ending December 31, 1889, are herewith appended, showing a commerce of $200,000 per year, about 9,152 tons.

This commerce would have easily reached $300,000 per year had it not been for the insufficient depth of the canal owned by private parties, forcing vesels to use the Core Sound route.

(6) *Recommendations for future work.*—It is recommended that this improvement be extended in general accord with the projects of 1883 and 1884 over the whole distance through the New Berne and Beaufort Canal, as well as through Clubfoot River and Harlowe Creek, so far as to secure a channel of 5 feet depth at mean low water and 30 feet bottom width from the mouth of Harlowe Creek to the mouth of Clubfoot River, thus completing a 5-foot navigation from New Berne to Beaufort, at a total expense of $57,000, in addition to the funds available June 30, 1890, this amount to be appropriated in one sum; but that *no funds be made available until this canal shall be ceded to the United States free of charge.*

Smaller yearly appropriations, involving the alternate disorganization and reorganization of working parties, damage to unfinished work, extra superintendence and the deterioration of plant, may increase the cost of the work by from $1,500 to $4,000 per appropriation.

A personal inspection of this route in 1885 revealed the worthiness of this improvement. If well opened, this line would be of much value as a connecting link between Pamlico Sound and Beaufort Harbor, and would complete an otherwise already existing inland navigation from the Chesapeake to Beaufort, N. C. The dangers of ocean travel around Cape Hatteras and Cape Lookout are so great that some such 5-foot navigation for small vessels appears necessary between Pamlico Sound and Beaufort Harbor, and no similar navigation can be secured by any other existing route except at greatly increased expense. Further improvement over this route so as to secure a channel of more than 5 feet depth at low water is not recommended for the present.

After this improvement is completed, its proper maintenance may cost from $1,000 to $3,000 per year.

This water-way is in the collection district of Pamlico and Beaufort, N. C.

Money statement.

July 1, 1889, amount available		$10,757.55
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$2,355.67	
July 1, 1890, outstanding liabilities	5.00	
		2,360.67
July 1, 1890, balance available		8,396.88
Amount (estimated) required for completion of existing project		57,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. E. D. THOMPSON, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Wilmington, N. C., June 30, 1890.

CAPTAIN: I have the honor to submit the following report of operations for the improvement of water-way between New Berne and Beaufort, N. C., during the fiscal year ending June 30, 1890.

Dredging operations were in progress July 1, 1889, and continued until the 23d of that month, under an unfinished contract with the Alabama Dredging and Jetty Company dated January 25, 1889. During this time 8,654 cubic yards (scow measurement) were removed; of this amount 6,750 cubic yards were temporary dumpage which was redredged and removed in scows to the dumping grounds on the south side of Newport River.

As the total result of work under this contract there exists a channel of 30 feet bottom width and 5 feet depth at low water over a distance of 4,483 feet (50 to 60 feet width with 3½ to 4 feet depth over 6,310 linear feet) south from the oyster rocks at mouth of Harlowe Creek to the 4-foot contour in the Newport River. The funds available for the work were insufficient to carry the full depth of 5 feet entirely across the shoal.

The dumpage from 2,073 linear feet of the dredging was deposited in permanent embankment on the north side of the cut, the balance being removed in scows and deposited south of the main channel of the Newport River.

Recent inspections of the work of this and previous years show all to be in good condition and maintaining the depths to which the cuts were originally dredged.

In September, 1889, 378 linear feet of minor plank jetties, banked with oyster shells, were constructed on the mud flats near the mouth of Harlowe Creek, to repair breaks in lines of existing jetties.

These plank jetties have done good service and caused an appreciable deepening of the channel across the flats; from the effects produced by the present system it appears probable that a full depth channel, 200 feet wide, could be easily obtained across these flats by the construction of more substantial jetties rising above the high-tide line.

Navigation over the water-way has been more or less impeded at various times during the year by slides and fills in the New Berne and Beaufort Canal, owned by private parties; otherwise no trouble has been experienced.

The expenses for the fiscal year have been:

For dredging	$2,464.70
For purchase and construction of plant	14.62
For superintendence, including office expenses	207.60
For materials built into work	5.60
For manual labor	57.75
Total	2,750.27

No detailed surveys were made during the year.

No new lines of navigation have been established during the year, although about $3,000 worth of stock has been subscribed toward a steamer to ply from Swansborough to New Berne by this route.

The tons of freight carried in 1889 are estimated at 9,152 tons, about the same as for 1888. This amount would have been increased at least 4,500 tons had the New Berne and Beaufort Canal (owned by private parties) been navigable at all times.

Dredging operations were under the immediate charge of Inspector F. D. Perry, who rendered efficient service.

Very respectfully, your obedient servant,

E. D. THOMPSON,
Assistant Engineer.

Capt. W. H. BIXBY,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

When work commenced on this improvement, in 1883, there was no navigation or commerce by this route.

At present, vessels drawing 3½ feet make regular trips, except when prevented by slides, caves, and consequent insufficient depth in the New Berne and Beaufort Canal (owned by private parties as above stated.)

The improvement, though quite recent and still incomplete, has already brought about a reduction of about 25 per cent. in freight charge between New Berne and

INLAND WATER-WAY

BETWEEN

BEAUFORT AND NEW BERNE, N.C.

SCALE OF MILES

1 0.5 0 1 2

Compiled from U.S.C.S. Charts and surveys made by E.D. Thompson in 1868 & 69. Reduced and drawn in office of Capt. W.H. Bixby, Corps of Engrs. by P. Bressig in March 1890.

5 FT. DEPTH CONTOURS = — — —

PROPOSED CHANNEL = 30 FT. WIDTH
5 FT. DEPTH

Surveys made under direction of
Capt W. H. Bixby, U.S.A.

Official

Wm. H. Bixby
Capt of Engrs.

BRIDGE

BELL'S BRIDGE

NEUSE RIVER

TO NEW BERNE (DEEP WATER)
39 Miles from BEAUFORT.

CLUBFOOT CREEK

CANAL

BRIDGE

HARLOWE CREEK

OYSTER CR.

CORE CR.

WARE CR.

RUSSELL'S CR.

FLOOD

NEWPORT RIVER

BOAT ROUTE

CRAB PT.

GARLANCE CHANNEL

LEWIS THORO

TOWN CR.

Beaufort

PIVERS ISD.

TOWN MARSH

CARROT ISD.

BIRD'S ISD.

BOGUE SOUND

BOGUE BANKS

FORT MACON

HARBOR ENTRANCE

SHACKELFORD POINT

Morehead City

ATLANTIC OCEAN

INLAND WATER-WAY

BEAUFORT TO NEW BERNE

NEW BERNE

SCALE OF MILES

0 5 10 15

N.E.H.S.L. RIVER

CLUBFOOT CR.

CANAL

HARLOWE CR.

MOREHEAD CITY

BEAUFORT

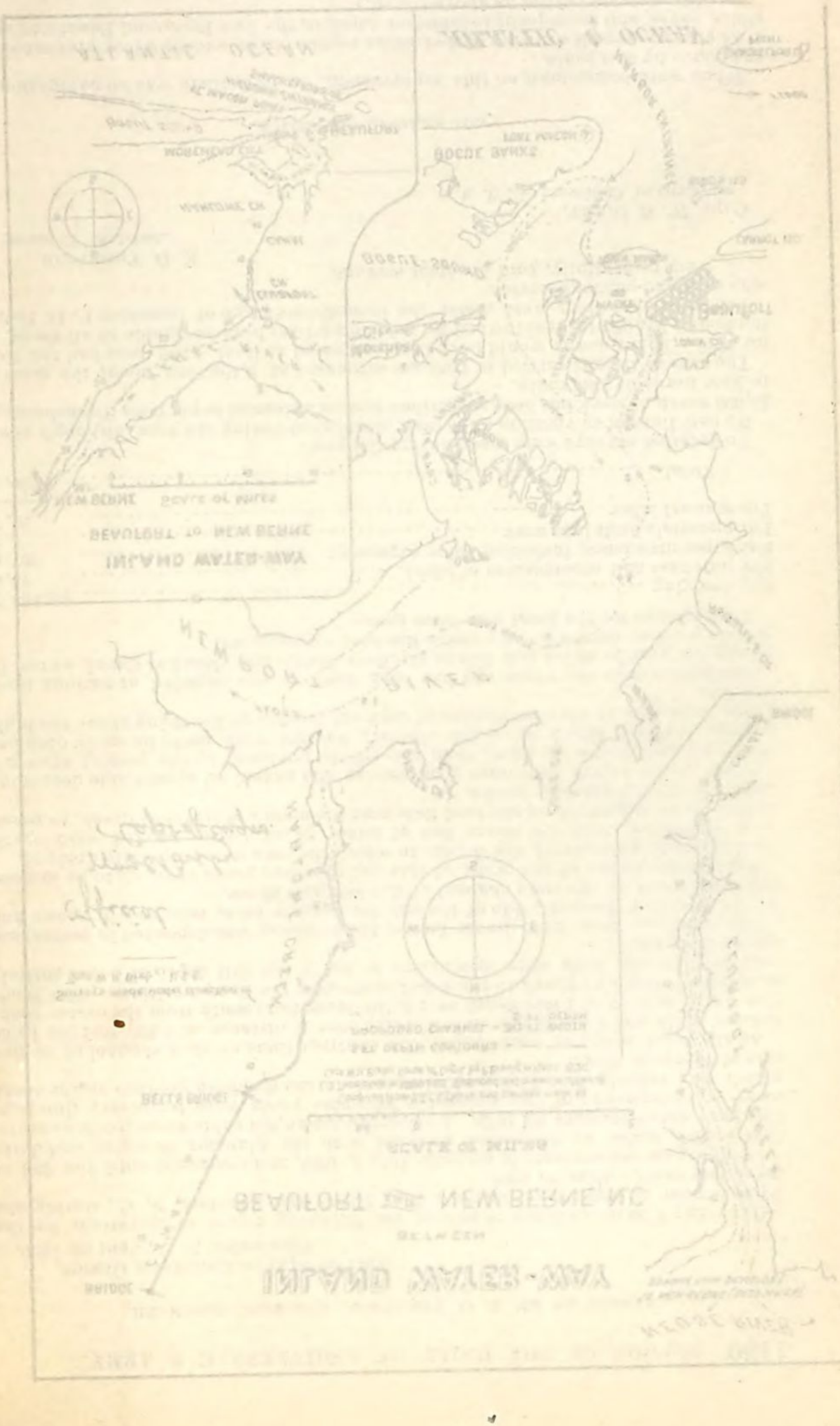
BOGUE SOUND

FT. MACON POINT

HARBOR-ENTRANCE

SHACKELFORD PT.

ATLANTIC OCEAN



Beaufort, and each dollar so far spent upon the improvement has been accompanied by the development of about $7 of annual commerce.

This water-way affords a short, nearly direct, route to all vessels able to use it, from Pamlico Sound, Neuse River, and their tributaries, to Beaufort Harbor, Core and Bogue Sounds, White Oak River and the ocean. It completes the existing line of inland navigation from Chesapeake Bay to Beaufort Harbor, and its final completion will insure a good 5-foot navigation at low water between these points, avoiding the dangers of Hatteras and Lookout and the shoals of Core Sound.

The commerce for the year ending December 31, 1889, is estimated as follows:

Class of goods.	Exports.	Imports.	Total.
Cotton and products	$60,000	.....	$60,000
Tobacco	.....	$6,000	6,000
Rice	8,250	.....	8,250
Grains and forage	.....	175	175
Vegetables and truck	4,500	.....	4,500
Live stock and products	2,800	2,600	5,400
Fish, oysters, etc	4,000	.....	4,000
Naval stores	6,000	.....	6,000
Lumber and products	36,000	.....	36,000
Fertilizers	2,000	.....	2,000
General merchandise	.....	67,000	67,000
Sundries	600	.....	600
Total	124,150	75,775	199,925

Total tonnage, 9,152 tons.

No new transportation lines established.

The above statistics are based mainly upon the reports of Assistant Engineer E. D. Thompson, made after much correspondence and conversation with steam-boat captains and agents, custom-house officials, and prominent shippers and merchants.

The commerce at present, as above shown, is (9,152 tons)	$199,925
The development of commerce since beginning of improvements is	199,925
Expended on improvements up to 31st December, 1889	26,496
The development of annual commerce for every dollar spent on the improvement since its commencement is	7

M 7.

IMPROVEMENT OF HARBOR AT BEAUFORT, NORTH CAROLINA.

HISTORY OF OPERATIONS.

(1) *Reference to past reports.*—For special description of harbor, see pages 1013–1017, Annual Report of 1881; for special history of past work, see page 989, Annual Report of 1886, and for maps of harbor, see page 1076, Annual Report of 1885, and page 1072 of 1889.

(2) *Original condition.*—Beaufort Harbor, at the eastern terminus of the Atlantic and North Carolina Railroad, is the only harbor of any importance between Chesapeake Bay and Wilmington, N. C., a distance of over 300 miles. It is especially valuable as the natural outlet to the inland commerce of northern and middle North Carolina, and as a natural harbor of refuge to vessels overtaken on this most exposed portion of the Atlantic coast. If its channel were marked by range lights it would be one of the easiest harbors to enter between the Chesapeake and Savannah.

When placed under governmental improvement, in 1880, this harbor possessed a bar entrance of 15.3 feet least depth at mean low water, with an average rise and fall of tide of 3 feet. At this time, however, the harbor entrance was rapidly deteriorating; its width, measured

from Fort Macon Point to Shackleford Point, having increased 500 feet between the years 1864 and 1880, and 900 feet more between the years 1880 and 1881; and its bar having rapidly and proportionately shoaled. From the bar, the harbor possessed a channel of 25 feet depth for 3.7 miles up to the Atlantic and North Carolina railroad wharf at Morehead City, and a branch channel of 9 feet depth for 0.6 miles up to Bulkhead Channel, and of 2 feet minimum depth for 0.6 miles further to the wharves of Beaufort City, where coasting vessels had a good wharfage of 7 feet depth and 1,800 feet length. Its commerce is now estimated to have been about $1,000,000.

(3) *Plan of improvement.*—The original project of 1881 proposed to stop the erosion at Shakleford Point by jetties; to extend the 9-foot depth of water from Bulkhead Channel to Beaufort City by a cutting 200 feet wide, and thence to dredge a 6-foot channel 100 feet wide to North River and Core Sound for the accommodation of the small craft of the neighboring sound. The projects of 1881, 1882, and 1884, as continued to date, proposed to secure this harbor by stopping further erosion of the sand-banks at Shackleford Point and Fort Macon Point, and thus stopping further deterioration of the bar entrance, and proposed to open a 5-foot channel 100 feet wide to Beaufort City. A personal examination of the locality and work in 1884 revealed the need of such work and its importance. Inadequate yearly appropriations and their consequences (the alternate disorganization and reorganization of working parties, damage to unfinished work, extra superintendence, and deterioration of plant) have added considerably to the cost of the work.

The total final cost of this work was estimated in 1887 at $163,000.

The aggregate amount appropriated for these projects up to June 30, 1890, is $125,000.

The funds now on hand will all be used up before new appropriations can become available.

(4) *Results.*—Up to June 30, 1889, a total of $101,972.62 had been spent in all upon this improvement in successfully stopping the erosion of Shackleford Point and Fort Macon Point, in arresting the shoaling upon this bar, and in making a careful survey of the present condition of the harbor entrance preparatory to the definite location of further works.

No special improvement of commerce nor of depth of water was thereby expected or obtained, but the retrograde movement had been in general arrested, the old shore-lines had reformed to a considerable extent as desired, and the former good condition of the harbor entrance was being rapidly established. The commerce was then about $1,300,000 of goods exported and imported.

(5) *Work of past year.*—The special work of the past year is as follows: Expenditures $20,061.81; value of United States plant, $3,400.

During the first part of the year, 1 contract dredge and scow, 2 large United States stone-scows, and other plant were in use.

Owing to its variable features and the difficulty of properly specifying it beforehand and measuring it afterwards, the placing of stone and all minor work was, for advantage and economy, allowably done by hired labor, and the purchase of materials in open market.

The dredging was carried on under contract with C. T. Caler, of Norfolk, Va., dated January 28, 1889, to be finished before September 6, 1889; the delivery of stone, under contract with Francis H. Smith, of New York City, dated January 24, 1889, to be finished before December 1, 1889.

Between July 1 and 12, 1,800 cubic yards of mud, clay, and sand

were dredged from the proposed channel, so as to leave a final cut of about 1,960 feet length, from 25 to 50 feet wide, and of at least 5 feet depth at low water completely across the Beaufort City shoal. The dumpage was used to fill up undesirable sloughs through the neighboring marsh.

The existing contract was satisfactorily completed on July 12, 1889.

Between July 1, 1889, and February 12, 1890, there were delivered and put in place 5,190.58 tons of stone, distributed as follows:

At Shackleford Point.—2,942.41 tons, viz: On the East (Core Sound) Jetty, 1831.12 tons; on Middle Jetty, 153.30 tons; on Main Jetty, 155.37 tons; on east spur of Main Jetty, 172.92 tons; on west spur of Main Jetty, 190.90 tons; on shore revetments (1045 linear feet), 438.80 tons.

At Fort Macon.—2,248.17 tons, viz: Railroad Jetty, 1,185.35 tons; Jetty No. 6, 79.72 tons; Jetty No. 5, 83.26 tons; Jetty No. 2, 147.04 tons; Main Jetty (including spur), 215.53 tons; shore revetments (1,879 linear feet), 537.27 tons.

All work of delivery of stone was stopped on February 12, 1890, by the satisfactory completion of contract.

There were built in place at Shackleford Point 3,008 linear feet of movable catch-sand fence, and at Fort Macon 2,716 linear feet of similar fence.

These fences and some of those previously built were, from time to time, raised a foot or two as sand accumulated about them, this accumulation being found to take place very rapidly and in a highly satisfactory manner.

Two thousand nine hundred and twenty-four linear feet of the shore revetments have been raised to about 1 foot above high-water mark.

During the year several minor surveys have been made of past work and of the shore-lines at both Shackleford Point and Fort Macon as a check upon the effect of past work, and to obtain data for the proper prosecution, record, and comparison of future work.

Inspections of property and work were made several times during the year. These inspections showed marked successful results at all the jetties, brush and stone revetments, and fences and crib-work of past years. The shore-line is now rapidly building out towards the ocean at points where it formerly was cutting away the most quickly.

The work of this improvement during the past year has been vigorously and very efficiently carried on under the immediate supervision of Assistant Engineer E. D. Thompson.

The work of the past year has much assisted in the preservation of this harbor. The channel cut through Beaufort City shoal has widened considerably under the influence of the tidal scour, and now affords an easy route from the entrance of the harbor to the city wharves.

Most of the jetties have been raised to about the high-tide line.

The shore revetments have assisted in the preservation of the beach, and the sand-fences have been markedly successful in building up the area reclaimed from the ocean.

The Shackleford Channel and the available depth on the bar have both been greatly improved.

Shackleford Point is rapidly moving back to its best condition of nearly fifty years ago. Otherwise the situation remains about the same as at the beginning of the fiscal year.

The latest reliable commercial statistics, those for the year ending December 31, 1889, are herewith appended, showing a commerce of $2,154,500 per year (about 60,000 tons).

(6) *Recommendations for future work.*—It is recommended that the

present approved projects be completed so far as to thoroughly protect Shackleford and Fort Macon points from further erosion, and to dredge a reduced channel of 100 feet width and 7 feet depth at low water from Bulkhead Channel entirely through to Beaufort City, at a total expense of $38,000, in addition to the funds available on June 30, 1890, this amount to be appropriated in one sum during the next year. Smaller yearly appropriations, involving the alternate disorganization and reorganization of working parties, deterioration of unfinished work, extra superintendence, and deterioration of plant, may increase the cost of the work by from $3,000 to $5,000 per appropriation.

Further improvement in accord with the original project, so as to secure to Beaufort City a channel of over 7 feet depth at low water from Bulkhead Channel, is not recommended at present. This improvement once thoroughly completed should be permanent. The harbor entrance needs a pair of range lights visible to a distance of 6 miles. It would then be of great value as a harbor of refuge. The least depth of water in this bar could probably be easily increased to 18 feet at low water, as it is said to have been in 1737 and 1830; $300,000 would probably cover the entire cost of this increase of depth.

Beaufort is a port of entry.

Money statement.

July 1, 1889, amount available		$23,027.38
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$19,887.34	
July 1, 1890, outstanding liabilities	174.47	
		20,061.81
July 1, 1890, balance available		2,965.57
Amount appropriated by act of September 19, 1890		15,000.00
Amount available for fiscal year ending June 30, 1891		17,965.57
Amount (estimated) required for completion of existing project		23,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		23,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. E. D. THOMPSON, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Wilmington, N. C., June 30, 1890.

CAPTAIN: I have the honor to submit the following report on the improvement of the harbor at Beaufort, N. C., for the fiscal year ending June 30, 1890.

All work was in progress July 1, 1889.

Under an unfinished contract for dredging with Mr. C. T. Caler, dated January 28, 1890, work was continued on the Beaufort City channel from July 1 to July 12, 1889, when the funds allowed for this dredging were exhausted. During this time 1,806 cubic yards (scow measurement) were removed, of which 326 yards were taken from the channel (the cutting being 200 feet long and 40 feet wide with a depth of 5 feet at low tide) and 1,474 yards were taken from a shoal L that obstructed the free flow of tide through the dredged cut.

The work done under this contract is summarized as follows:

Dug under the contract	yards..	12,280
Dredging completed (20 to 50 feet wide, 5 feet deep at low water)	linear feet..	1,810
Channel completed (150 feet not dredged)	do....	1,960
Length of cuts, each 20 feet wide, made on shoal L		1,190

A small dipper-dredge was used by the contractor; all material was removed in scows and used in filling sloughs that it was desirable to close.

The work so far done allows vessels of 8 feet draught to enter the inner harbor at high tide. An examination of the dredged cut made in May, 1890, showed that scour

both on bottom and sides is taking place, all indications being that the channel will remain permanent.

Under an unfinished contract with F. H. Smith, of New York City, dated January 24, 1889, delivery of rubble-stone continued from July 1, 1889, until February 12, 1890, when the contract was satisfactorily completed. During this period 5,190.58 tons were received and placed as follows:

At Fort Macon Point:

	Tons.	Tons.
On railroad jetty	1,185.35	
On Jetty No. 6	79.72	
On Jetty No. 5	83.26	
On Jetty No. 2	147.04	
On main Jetty, including spur	215.53	
On shore revetment	537.27	
		2,248.17

At Shackleford Point:

On east jetty	1,831.12	
On middle jetty	153.30	
On east spur	172.92	
On west spur	190.90	
On main jetty	155.37	
On shore revetment	438.80	
		2,942.41
Total		5,190.58

At Fort Macon Point.—The railroad jetty, having a foundation length of 200 feet, was raised to 1 foot above high tide over 190 feet of its length.

This jetty has now about 25 feet of water at its outer end and is completed for the present. The sand is rapidly accumulating on the eastward or flood-tide side, where the depth of water has been reduced from 45 feet in 1887 to about 16 feet in 1890. The shore-line is developing in a very satisfactory manner.

Jetty No. 6, having a foundation length of 70 feet, was completed to 1 foot above high tide line over 60 feet of its length; jetty No. 5, with a foundation length of 140 feet, was completed to 1 foot above high tide line over the entire distance; Jetty No. 2 was repaired by having 147 tons of large stone, in pieces of from 900 to 2,000 pounds weight, placed on its sea end; the length of jetty was thus increased 10 feet on the high-tide line, while the entire structure was greatly strengthened.

The main jetty (No. 4) was faced with large stone over 100 feet of its ocean side and 200 feet of its harbor side; the sea end was in particular heavily riprapped with pieces weighing 1,500 to 2,000 pounds each, and the spur, 150 feet long on its foundation, was raised to 1 foot above high tide over 130 feet of its length.

Shore revetment was laid as follows:

	Linear feet.
From Jetty No. 5 to the sand-hills, 10 feet wide	91
From railroad jetty to main jetty, 6 feet wide	1,879

This latter revetment has a brush foundation, is 6 feet wide, and rises 3 feet in the center, located between the high and low tide lines, and extending continuously from the railroad jetty to the main jetty; it has, since its completion, effectually prevented all erosion of the shore behind it, and is developing a new high-tide line along its crest.

At Shackleford Point.—The east jetty, having a total foundation length of 402 feet and extending out to 25 feet depth of water at low tide, has been raised to 1 foot above high-tide line over 380 feet of its length, completing it for the present.

The middle jetty, having a foundation length of 150 feet and originally extending out to 12 feet of water at low tide, has been entirely completed, and for 140 feet of its length is 1 foot above high tide.

The accumulations of sand on the west or flood-tide side of this jetty have been so great that the low-tide line now touches the outer end of the jetty. This structure replaced the old middle jetty, which had almost washed away when the present jetty was commenced.

The east and west spur-jetties, with foundation lengths of respectively 170 and 150 feet, have been raised to 1 foot above high-tide line as follows: East spur, 150 feet of length; west spur, entire length. These jetties originally extended out to 3 feet depth of water at low tide, but the outer ends are now bare at low water.

On the main jetty the large stone facing, in continuation of last year's work, was completed over a distance of 250 feet on the Core Sound side and 110 feet on the ocean side.

This jetty, as completed, is in excellent shape; it has a total foundation length of 595 feet, is capped by 25 blocks of concrete, each 20 feet by 6 feet by 3 feet, and heavily riprapped the entire length of the ocean side and for 370 feet of the sound side; this

atter side is further protected by a spur-jetty (west spur) and a revetment along the adjacent shore.

Shore revetments of brush and stone were laid as follows:

Between the middle and main jetties 1,045 linear feet. This, like the Fort Macon revetment, has a base of 6 feet and a center height of 3 feet; it rises 1 foot above high-tide line; it has been very successful in completely arresting the erosion of the sand-banks behind it.

Sand-fences.—Of these, in continuation of last year's work, 3,008 linear feet have been built at Schackleford and 2,716 feet at Fort Macon.

The fences are in movable sections of 16 feet length, and built upon the same general plan as last year, only smaller, the frames being 30 inches long on the inclined face and covered with three 8-inch boards with openings of three-fourths of an inch between them. This small inclined fence gathers sand quite as readily as the larger inclined or vertical fences, and is by far more economical in construction and maintenance. Until February 15, 1890, the fences were raised from time to time whenever the deliveries of stone would permit; since that date a regular force of two men has been employed for that work and is hardly able to keep up with it.

At both Macon and Schackleford excellent results have been obtained by the use of these fences, the accumulations of sand in many places being already 10 to 12 feet high and constantly increasing.

Detailed surveys.—Of these, several have been made during the year, the more important being in May, 1890, a survey of Shackleford shore-line, of the inlet and bar, of the bulkhead at entrance to Bulkhead Channel, of Gallance Channel west of Beaufort, and of the railroad jetty. Other surveys made at various times were mainly for the determination of the new shore-lines developed by the jetties. The high winds of the past winter, with accompanying heavy seas, caused a recession of the high-tide line south of the main jetty at Shackleford, but the beach is again reforming. The shoal off against Shackleford now extends to the main channel, and carries 3 to 7 feet at low water. The least depth of water on the bar is, according to the recent survey, 14 feet at low water, the average depth being 17 to 18 feet; 13 feet can be carried at high water from the ocean through the new Shackleford Channel to the "straits."

The expenditures of the year to July 1, 1890, are as follows:

Materials built into work	$11,584.25
For dredging by contract	675.00
For purchase, construction, and for repair of property	146.90
For manual labor	4,213.06
For superintendence, surveys, office expenses, etc	1,672.57
Total	18,291.78

Distributed as follows:

Construction of jetties, including revetments	$16,486.19
Construction of sand-fences	804.31
Raising sand-fences	221.28
Dredging	780.00

The cost of each particular feature of work has been per unit as follows:

Receiving and placing stone per ton	1.09+
Construction of sand-fences per section	2.72
Maintenance of sand-fences per section	0.067+

Dredging per cubic yard, 43 cents. (Cost per unit, based on work of two years)

The work of the past season has practically completed all jetty work needed for the present, with the exception of the sea end of Jetty No. 1, at Fort Macon Point, where some large stone (about 200 tons) could be used advantageously for its future protection. The principal work therefore remaining to be done under the present project is the widening and deepening of the dredged channel in front of Beaufort, at an estimated cost of $22,000, this amount including also the deepening of the Bulkhead Channel to 7 feet depth.

No new lines of transportation have been established during the year, although $3,000 has been subscribed toward a steam-boat to ply between Swansborough and New Berne, touching at Beaufort.

The tons of freight transported during the calendar year of 1889 are estimated at 21,545, an increase of 4,660 tons over 1888.

Messrs. John A. Dill, J. C. Long, and John B. Ives have had charge respectively of jetty construction, dredging operations, and the clerical work, and all have rendered efficient service.

Very respectfully, your obedient servant,

E. D. THOMPSON,
Assistant Engineer.

Capt. W. H. BIXBY,
Corps of Engineers, U. S. A.

PROGRESS MAP FOR 1890

BEAUFORT HARBOR, N.C.

FROM 1. JULY 1889 TO 30. JUNE 1890.

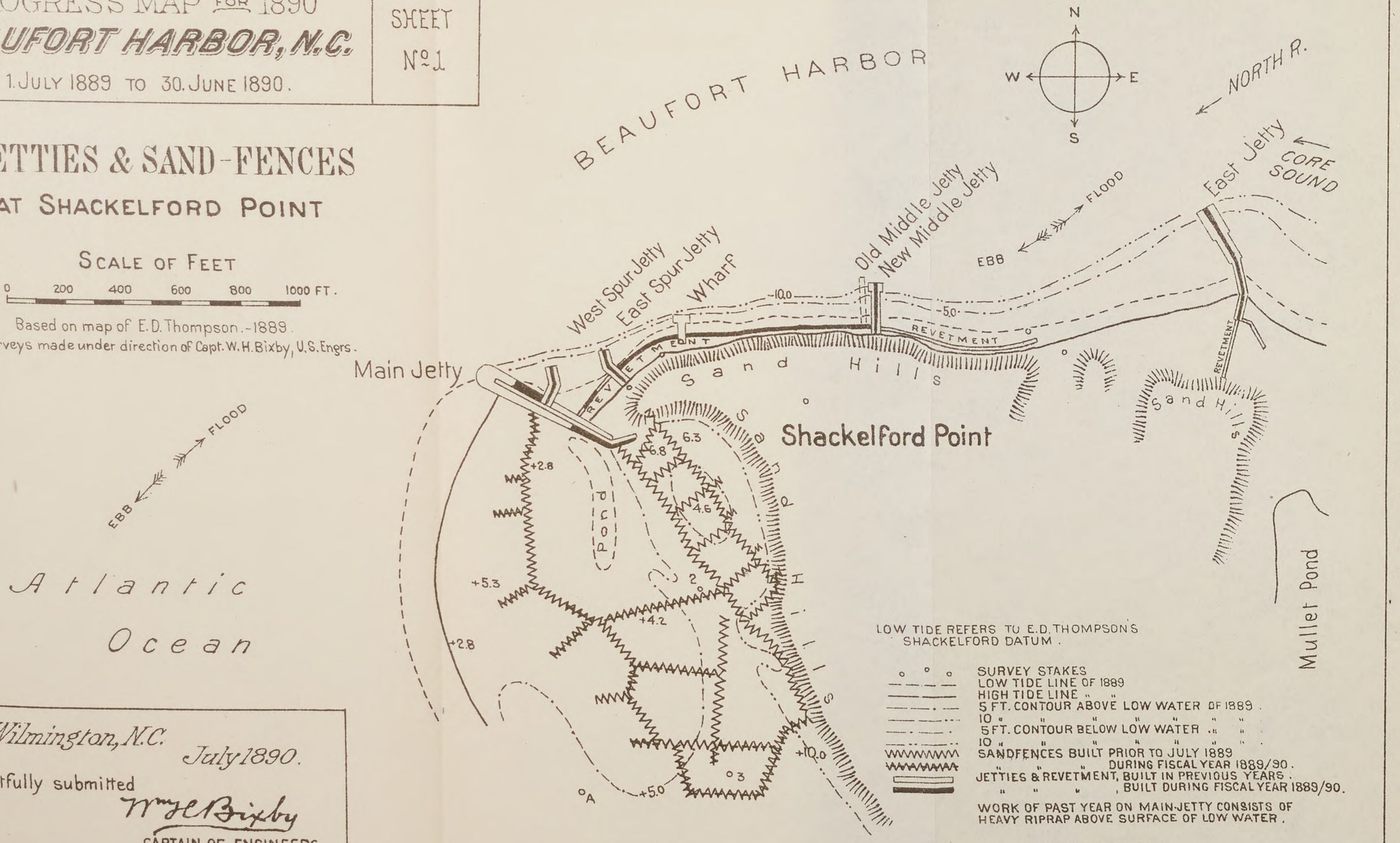
SHEET Nº 1.

JETTIES & SAND-FENCES AT SHACKELFORD POINT

SCALE OF FEET

0 200 400 600 800 1000 FT.

Based on map of E.D. Thompson.-1889.
Surveys made under direction of Capt. W.H. Bixby, U.S. Engrs.



LOW TIDE REFERS TO E.D. THOMPSON'S SHACKELFORD DATUM.

- SURVEY STAKES
- LOW TIDE LINE OF 1889
- HIGH TIDE LINE " "
- 5 FT. CONTOUR ABOVE LOW WATER OF 1889.
- 10 " " " " " " " "
- 5 FT. CONTOUR BELOW LOW WATER " "
- 10 " " " " " " " "
- SANDFENCES BUILT PRIOR TO JULY 1889
- " " " DURING FISCAL YEAR 1889/90.
- JETTIES & REVETMENT, BUILT IN PREVIOUS YEARS.
- " " " , BUILT DURING FISCAL YEAR 1889/90.

WORK OF PAST YEAR ON MAIN-JETTY CONSISTS OF HEAVY RIPRAP ABOVE SURFACE OF LOW WATER.

DRAWN BY P. BROSIG.

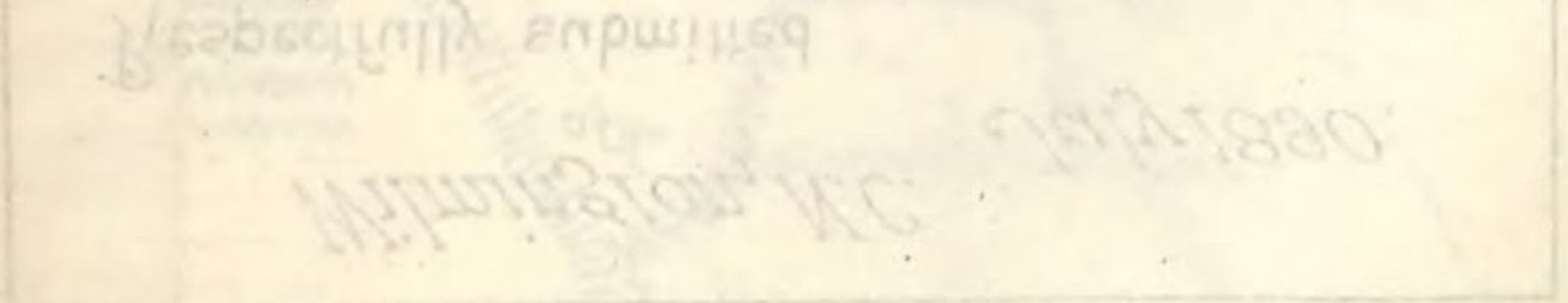
Wilmington, N.C. *July 1890.*

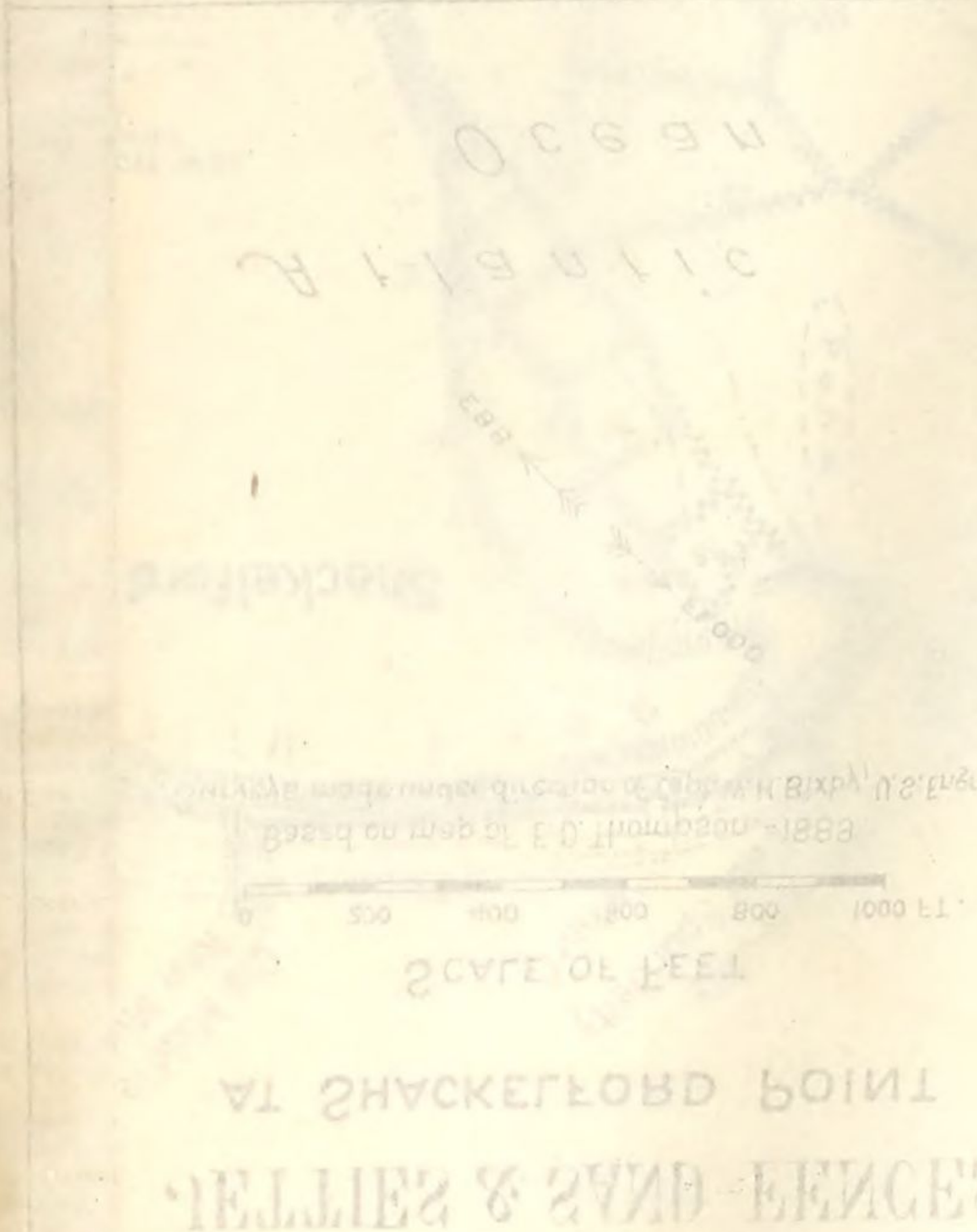
Respectfully submitted

Wm. H. Bixby

CAPTAIN OF ENGINEERS

Eng 90





PROGRESS MAP FOR 1890.

BEAUFORT HARBOR, N.C.

FROM 1 JULY 1889 TO 30 JUNE 1890

SHEET Nº 2.

JETTIES

AT SHACKELFORD POINT

Surveys made under direction of Capt. W.H. Bixby, U.S. Engrs.

SCALE OF FEET.

HORIZONTAL 0 50 100 150 200 FEET

VERTICAL 0 5 10 15 20 FEET

LOW TIDE REFERS TO E.D. THOMPSON'S SHACKELFORD DATUM

WORK OF PREVIOUS YEARS.

WORK OF FISCAL YEAR 1889-90.

UNCOMPLETED WORK.

Wilmington, N.C. July 1890.

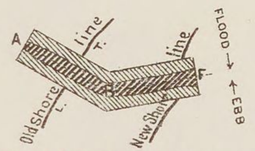
Respectfully Submitted

W.H. Bixby

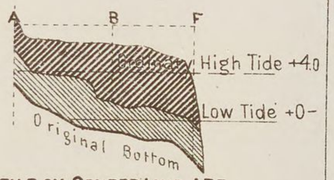
CAPTAIN OF ENGINEERS

WEST SPUR





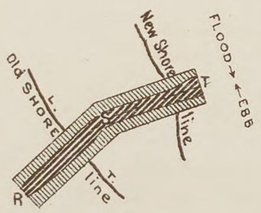
PLAN OF MATTRESS FOUNDATION



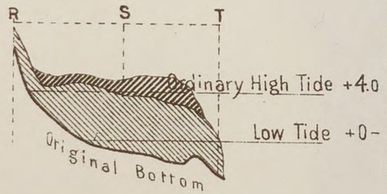
PROFILE ON CENTERLINE ABF

EAST SPUR



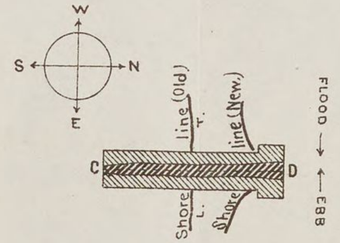


PLAN OF MATTRESS FOUNDATION

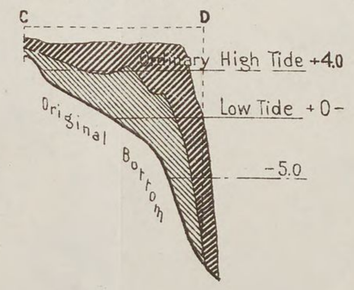


PROFILE ON CENTER LINE RST.

NEW MIDDLE JETTY

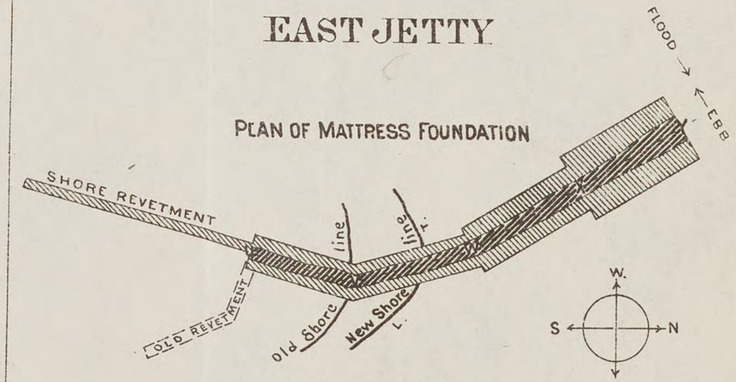


PLAN OF MATTRESS FOUNDATION

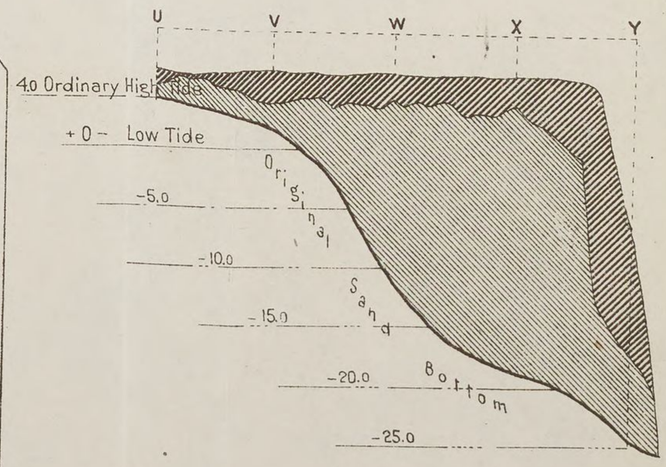


PROFILE ON CENTER LINE CD.

EAST JETTY



PROFILE ON CENTER LINE UVWXY.



DRAWN BY P. BROSIG.

Eng 90

UNCOMPLETED WORK

WORK OF FIRST YEAR 1880-81.

WORK OF SECOND YEAR.

SCALE OF FEET

0 20 40 60 80 100 FEET

HORIZONTAL

0 5 10 15 20 30 FEET

VERTICAL

CAPTAIN OF ENGINEERS

AT SHACKLEFORD POINT

SHEET 2

PROGRESS MAP FOR 1890.

BEAUFORT HARBOR, N.C.

FROM 1. JULY 1889 TO 30. JUNE 1890.

SHEET Nº3

JETTIES & SAND-FENCES
AT FORT MACON POINT

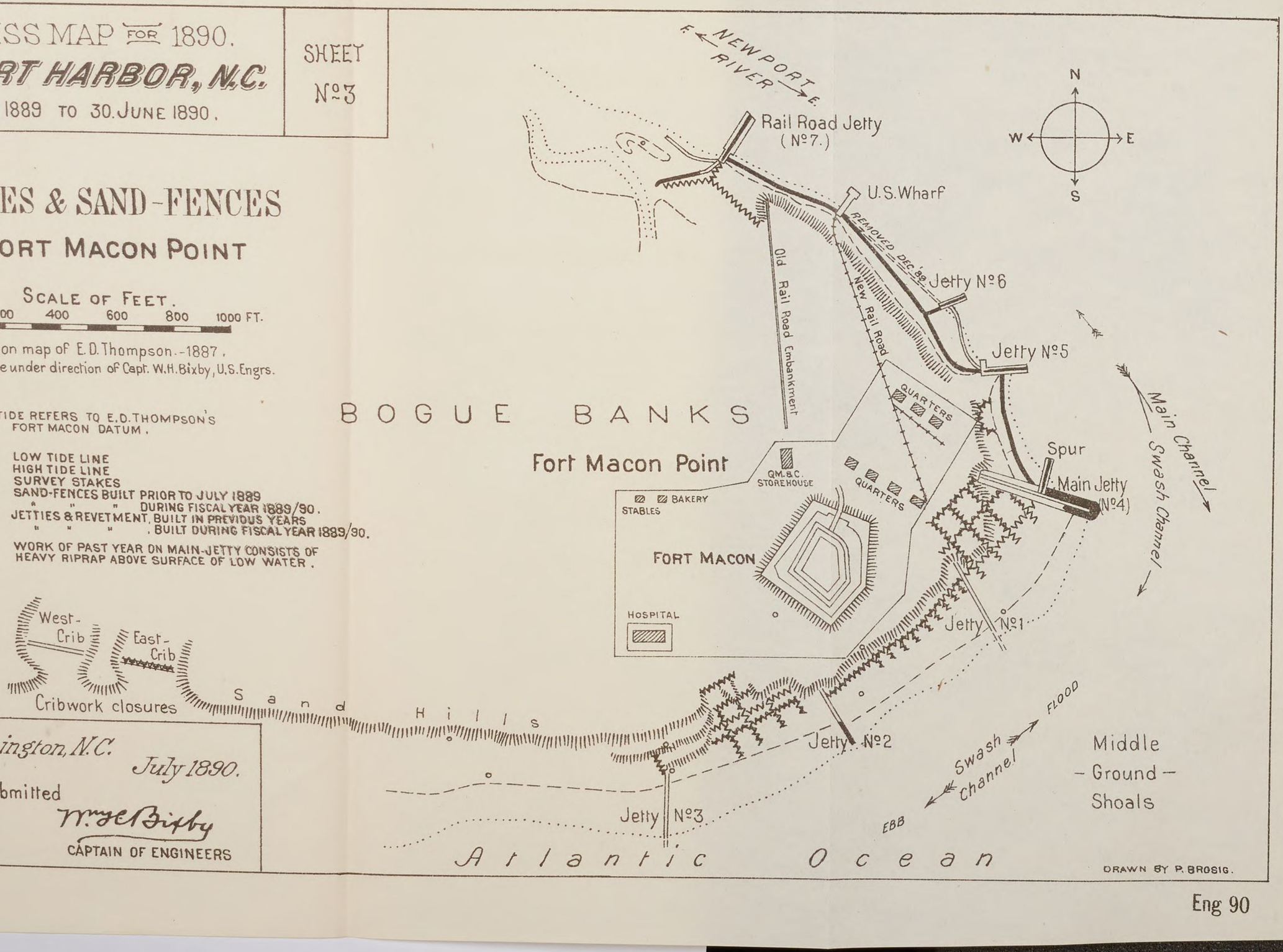
SCALE OF FEET.
0 200 400 600 800 1000 FT.

Based on map of E.D. Thompson.-1887.
Surveys made under direction of Capt. W.H. Bixby, U.S. Engrs.

LOW TIDE REFERS TO E.D. THOMPSON'S FORT MACON DATUM.

LOW TIDE LINE
HIGH TIDE LINE
SURVEY STAKES
SAND-FENCES BUILT PRIOR TO JULY 1889
" " " DURING FISCAL YEAR 1889/90.
JETTIES & REVETMENT, BUILT IN PREVIOUS YEARS
" " " , BUILT DURING FISCAL YEAR 1889/90.

WORK OF PAST YEAR ON MAIN-JETTY CONSISTS OF HEAVY RIPRAP ABOVE SURFACE OF LOW WATER.



DRAWN BY P. BROSIG.

Wilmington, N.C. *July 1890.*

Respectfully submitted

W.H. Bixby

CAPTAIN OF ENGINEERS

BENNETT'S & SAND-FENCES

AT FORT MACON POINT

BEAUFORT HARBOR, N.C.

PROGRESS MAP FOR 1890.

JANUARY 1889 TO 30 JUNE 1890.

No. 2

SHEET

PROGRESS MAP FOR 1890

BEAUFORT HARBOR, N.C.

FROM 1 JULY 1889 TO 30 JUNE 1890

SHEET Nº 4.

JETTIES

AT FORT MACON POINT

SCALE OF FEET

HORIZONTAL 0 50 100 150 200 FEET

VERTICAL 0 5 10 15 20 FEET

LOW TIDE REFERS TO E.D. THOMPSON'S FORT MACON DATUM

WORK OF PREVIOUS YEARS

WORK OF FISCAL YEAR 1889-90

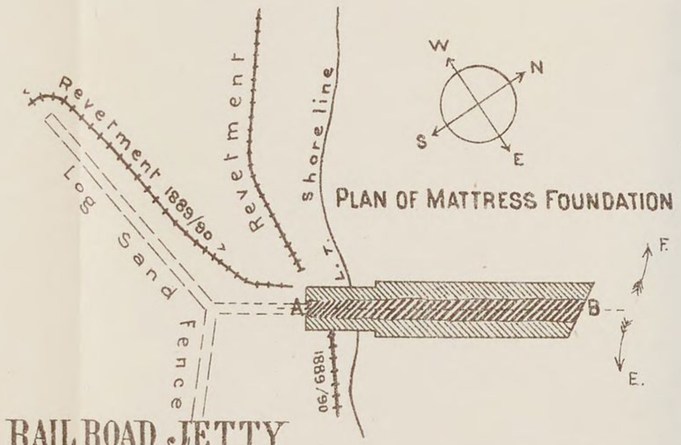
UNCOMPLETED WORK

Wilmington N.C. July 1890.

Respectfully submitted

W. H. C. Bixby

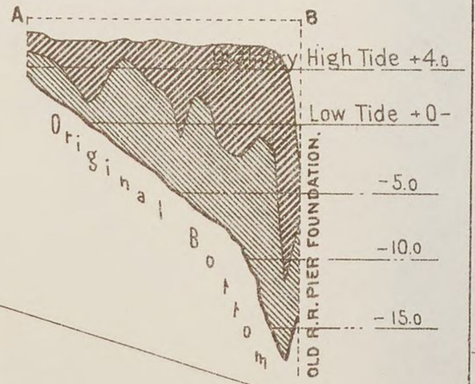
CAPTAIN OF ENGINEERS

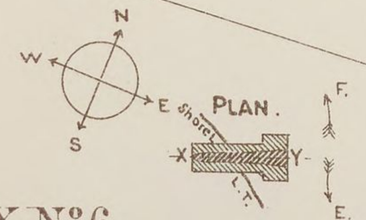


PLAN OF MATTRESS FOUNDATION

RAIL ROAD JETTY (Nº 7)

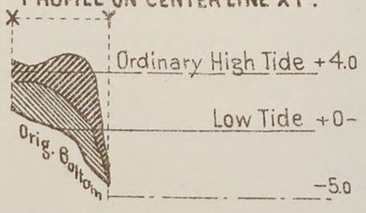
PROFILE ON CENTER LINE AB.

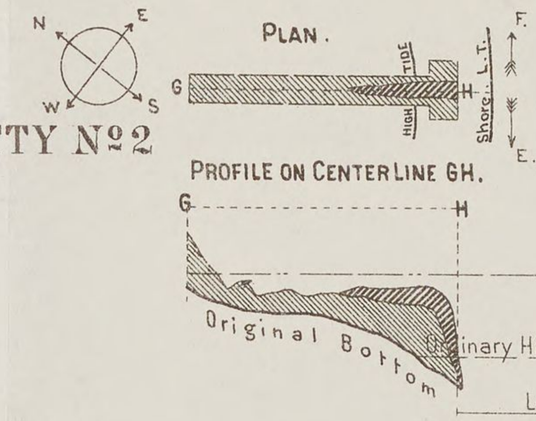




JETTY Nº 6

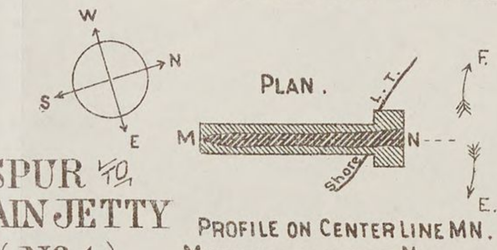
PROFILE ON CENTER LINE XY.





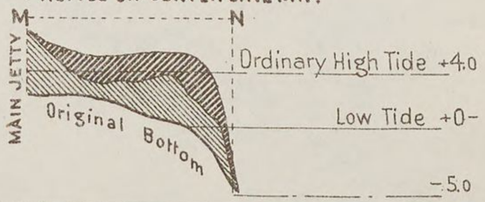
JETTY Nº 2

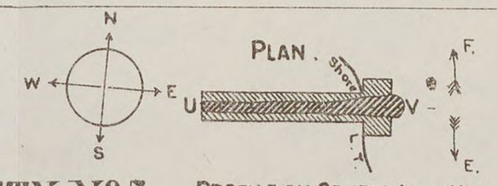
PROFILE ON CENTER LINE GH.



SPUR TO MAIN JETTY (Nº 4.)

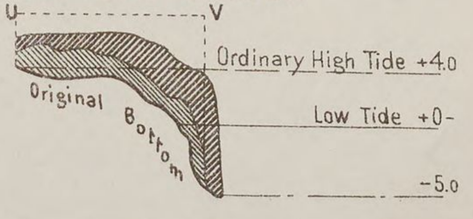
PROFILE ON CENTER LINE MN.





JETTY Nº 5

PROFILE ON CENTER LINE UV.



UNCOMPLETED WORK

WORK OF FISCAL YEAR 1989-90

WORK OF PREVIOUS YEARS

SCALE OF FEET

AT FORT MACON POINT

PROGRESS MAP FOR 1890

FROM JULY 1889 TO 30 JUNE 1890

Respectfully submitted

CAPTAIN OF ENGINEERS

PROGRESS MAP FOR 1890

BEAUFORT HARBOR, N.C.

FROM 1. JULY 1889 TO 30. JUNE 1890.

SHEET Nº5

BEAUFORT CITY CHANNEL

SCALE

0 500 1000 1500 FEET.

Based on map of E.D. Thompson - 1888.
Surveys made under direction of Capt. W.H. Bixby, U.S. Engrs.

- ° ° ° SURVEY STAKES
- —·—·— 3 FT. CONTOUR AT LOW WATER
- DREDGING OF PREVIOUS YEARS
- DREDGING OF FISCAL YEAR 1889/90 TO 8. FT. DEPTH AT LOW WATER
- UNCOMPLETED CHANNEL
- DUMPAGE

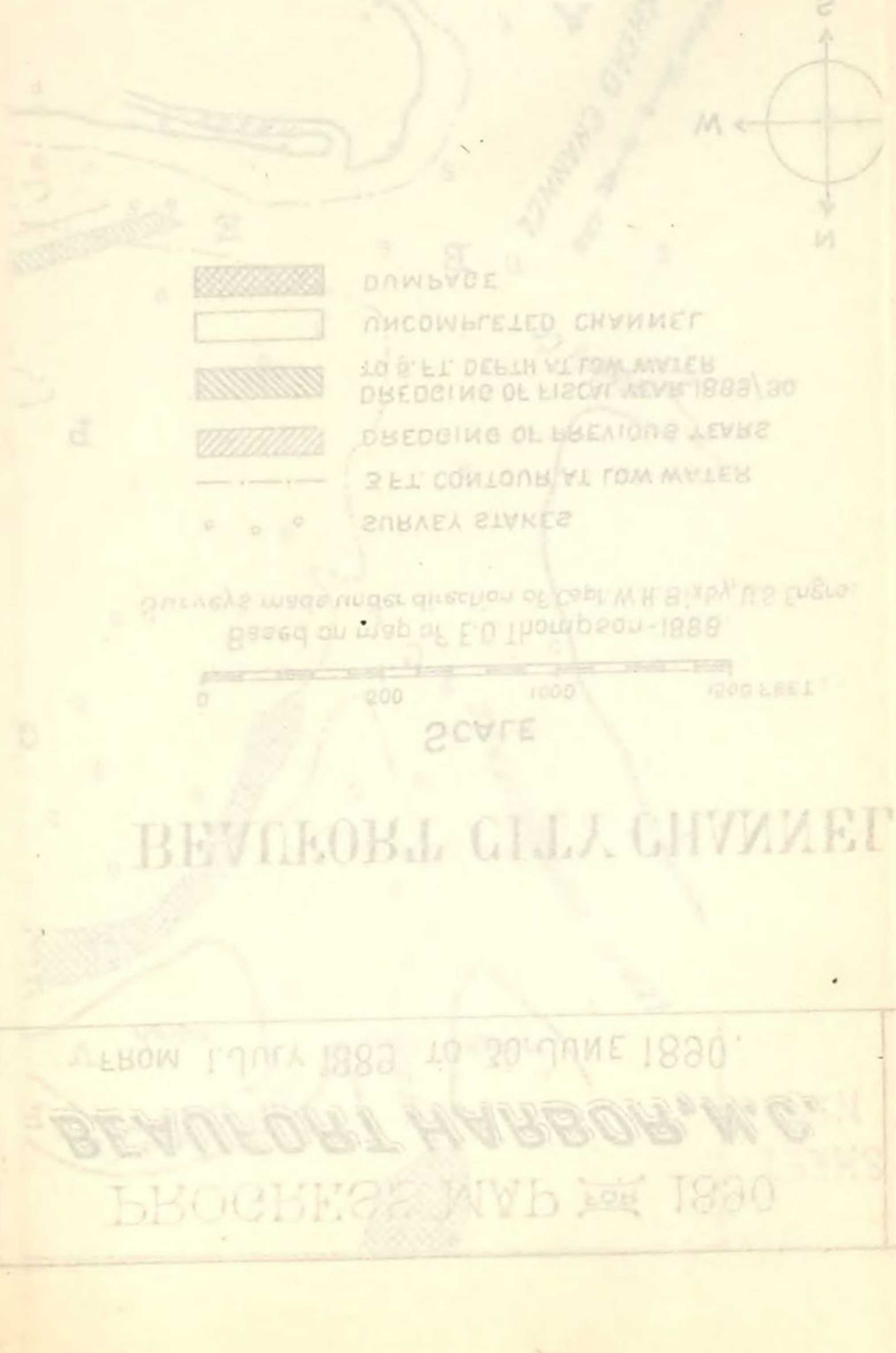
N W E S

Wilmington, N.C.
July 1890.

Respectfully submitted
Wm. H. Bixby
CAPTAIN OF ENGINEERS

Marsh
Creek
Still Island Creek
R
Marsh
V
GALLANCE CHANNEL
M
Gallance Creek
Mill Point
LEWIS THOROUGHFARE
C
R
Piver's Island
T
Beaufort
ANN ST.
MOORE ST.
FRONT ST.
ORANGE ST.
K
Q
S
ROCK
P
N
I
G
Reid's Cr.
FLOOD
EBB
BULKHEAD CHANNEL
B
E
F
A
CREEK
Town Marsh
Bird Shoal
D
Bird Shoal

DRAWN BY P. BROSIG.



BEAUFORT CITY CHANNEL

FROM JULY 1889 TO 30 JUNE 1890.

BEAUFORT HARBOR, N.C.

COMMERCIAL STATISTICS.

When this improvement was commenced in 1881 the sand-banks which limit the width of the harbor entrance were rapidly wearing away (a sixth of a mile in one year), and the harbor entrance bar was rapidly shoaling. The commerce is estimated to have then been about $1,000,000.

No marked improvement was expected or has been obtained in commerce or navigation or in the rates of freight and insurance. The deterioration has been stopped, and the former good condition of the harbor entrance is being re-established. The depth of water on the bar is now about 14 feet at low water. The commerce is now estimated to be about $2,154,500 per year.

This harbor, at the eastern terminus of the Atlantic and North Carolina Railroad, is the only harbor of special importance between Chesapeake Bay and Wilmington, N. C., a distance of over 300 miles. It is especially valuable as being the natural outlet of Albemarle and Pamlico sounds, and of the inland commerce of northern and middle North Carolina, and as being also a harbor of refuge for vessels overtaken on the exposed portion of the Atlantic coast, embracing Capes Hatteras and Lookout. If its channel were properly marked by range-lights, it would be one of the safest and easiest harbors to enter between the Chesapeake and Savannah. Large numbers of shallow-draught coasting vessels from the Tar, Pamlico, Trent, Contentnia, and Neuse rivers, and from Albemarle and Pamlico sounds, come by way of the New Berne and Beaufort Canal or Core Sound and pass through this harbor on their way south to Wilmington, Georgetown, Charleston, and Savannah, this harbor affording them a safe and convenient exit to the ocean, and permitting them to avoid the dangers of ocean navigation outside Hatteras or Lookout. The preservation and development of this harbor is of great importance to the whole State of North Carolina; its natural advantages are such that, with proper developments, this should become one of the principal harbors of the southern coast.

Summary.

Class of goods.	Exports.	Imports.	Total.
Cotton and products	$50,500	.....	$50,500
Tobacco	.....	$50,000	50,000
Rice	1,500	500	2,000
Grains and forage	.....	27,000	27,000
Vegetables and truck	62,500	.....	62,500
Live-stock and products	14,000	35,000	49,000
Fish, oysters, etc	220,000	.....	220,000
Naval stores	1,000	.....	1,000
Lumber and products	25,000	.....	25,000
Coal and minerals	.....	20,000	20,000
Fertilizers	1,000	3,000	4,000
Machinery	.....	3,000	3,000
General merchandise	100,000	303,000	403,000
Sundries	13,000	24,000	37,000
Total	488,500	465,500	954,000
Passing through the harbor	600,000	600,000	1,200,000
Grand total	1,088,500	1,065,500	2,154,000

	Tons.
Total tonnage	60,000
Gain during past year	4,660

No new transportation lines were established during the year.

Commerce before improvement	$1,000,000.00
Commerce at present	2,154,500.00
Development of commerce since improvement began	1,154,500.00
Expended on improvement to December 31, 1889	114,665.27
Development of annual commerce for every dollar spent	10.00

Movement of vessels.

Description.	Number.	Tons.
Sail-vessels owned at Beaufort, N. C	122	1,931
Steam-vessels owned at Beaufort, N. C	2	82
Sail-vessels built at Beaufort, N. C	18	.....
Vessels, increase over last year	5	.....
Vessels passed through Core Sound and out of Beaufort Harbor Inlet, including 20 steamers and 30 sail-vessels (estimated), yachts, and passenger boats	.....	*30,000
Sail-vessels arrived at Beaufort, N. C	(†)	.....
Steam-vessels arrived at Beaufort, N. C	(†)	.....
Sail-vessels departed from Beaufort, N. C	(†)	.....
Steam-vessels departed from Beaufort, N. C	(†)	.....

*Estimated. †No records kept.

Estimated as passing through the harbor, grain, general merchandise, phosphate, lumber, and sundries, 15,000 tons at $80, $1,000,000.

The above statistics are based mainly upon the reports of Assistant Engineer E. D. Thompson, made after much correspondence and conversation with steam-boat captains and agents, custom-house officials, and prominent shippers and merchants.

M 8.

IMPROVEMENT OF INLAND WATER-WAY BETWEEN BEAUFORT HARBOR AND NEW RIVER, THROUGH BOGUE SOUND, NORTH CAROLINA.

HISTORY OF OPERATION.

(1) *Reference to past reports.*—For special description of this sound, see pages 1135–1139, Annual Report for 1885; and for map of location of channel, see page 1074, Annual Report of 1889.

(2) *Original condition.*—Bogue Sound is an open water-way lying between the mainland and an outer line of sand-banks, extending from Beaufort Harbor 24 miles westward to Bogue Inlet and White Oak River, and being prolonged by narrow, crooked, tide-water creeks 17 miles further through salt-water marshes to New River, North Carolina.

The sound and marsh vary from 1 to 2 miles in width; the channels and creeks from 10 to 400 feet in width, and from 6 inches to 8 feet in depth; and the rise of tide from 0 to 5 feet according to location and prevailing winds. This water-way forms a portion of one of the proposed routes of inland navigation from the Chesapeake to Wilmington.

When placed under governmental improvement in 1886, this water-way possessed an 18-inch depth of channel at low water from Beaufort to the town of Swansborough, on White Oak River; thence a 3-foot depth at mid-tide 6 miles further to Bear Inlet and Creek; thence a 6-inch depth at low water 11 miles further to New River, whence boats of 5 feet draught could proceed 14 miles further to the town of Jacksonville. (See report on New River, North Carolina.) Its commerce is estimated to have then been about $200,000 per year, carried by sail-boats of less than 2 feet draught.

(3) *Plan of improvement.*—The original project of 1885, as continued to date, recommended the establishment of a channel of at least 3 feet depth at low water from Beaufort to Swansborough. Personal inspection has shown White Oak River basin to be agriculturally rich and apparently capable of adding $500,000 annual commerce to Bogue Sound as soon as the latter is open to 3-foot draught steamers.

The total final cost of this work was estimated in 1887 to be $50,000.

The aggregate amount appropriated for this project up to June 30, 1890, is $15,000.

(4) *Results.*—Up to June, 30 1889, a total of $14,595.06 had been spent in all upon this improvement in necessary surveys and in dredging so as to secure a channel of at least 40 feet width and 3 feet depth at ordinary high tide over the entire route.

In consequence of this work a small steamer had been built to ply between Beaufort and Swansborough. No special improvement of commerce was to be expected until the work is complete.

(5) *Work of the past year.*—The special work of the past year is as follows: Expenditures, $42 83; value of United States plant, $215.

Owing to its variable features and to the difficulty of properly specifying it beforehand and measuring it afterwards, all minor work was, for advantage and economy, allowably done by hired labor and the purchase of materials in open market.

The available funds on hand being nearly exhausted (field operations having been suspended in April 1889) no active work has been done during the past year. Office reports and records have been continued during the year and a small reserve has been kept for use in emergencies.

Government property has been stored and cared for at Beaufort, N. C.

Inspections of the work have been made during the year.

This improvement has been under the immediate and efficient supervision of Assistant Engineer E. D. Thompson, whose report is herewith appended.

As no work has been done during the past year, the situation remains about the same as at the beginning of the fiscal year.

The latest reliable commercial statistics, those for the year ending December 31, 1889, are herewith appended, showing a commerce of $418,400 per year, about 18,165 tons.

(6) *Recommendations for future work.*—It is recommended that the present approved project be completed, so far as to secure a continuous channel of 100 feet width and at least 3 feet depth at low water from Beaufort Harbor to Swansborough, White Oak River, and Bogue Inlet, at a total expense of $35,000 in addition to the funds available June 30, 1890, this amount to be appropriated in one sum. Smaller yearly appropriations, involving the disorganization and reorganization of working parties, damage to unfinished work, extra superintendence, and deterioration of plant, etc., may increase the cost of the work by from $2,000 to $6,000 per appropriation.

Further improvement, so as to extend the navigation to New River, is not recommended at present. The improvement once thoroughly finished should remain comparatively permanent.

This water-way is in the collection district of Beaufort, N. C.

Money statement.

July 1, 1889, amount available	$404.94
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	42.83
July 1, 1890, balance available	362.11
Amount appropriated by act of September 19, 1890	15,000.00
Amount available for fiscal year ending June 30, 1891	15,362.11
Amount (estimated) required for completion of existing project	20,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	20,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. E. D. THOMPSON, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Wilmington, N. C., June 30, 1890.

CAPTAIN: I have the honor to submit the following report on the improvement of water-way between Beaufort Harbor and New River, North Carolina, for the fiscal year ending June 30, 1890.

On account of lack of funds no work has been done on this improvement during the year.

Examinations of the dredged cuts made in May, 1890, showed that all past work was in a satisfactory condition; the depths to which the channels were originally dredged are being well maintained, and the cuts are in constant use by all craft.

As stated in last year's report, there still remains to be dredged to secure a continuous chanel 8,550 feet between Sander's Creek and Sander's Wharf and 200 feet at Sally Bell's Shoal.

No detailed surveys have been made during the year.

The expenses have been as follows:

For general superintendence	$10.50
For purchase of plant	6.50
	17.00

No new lines of transportation have been established during the year, although about $3,000 worth of stock has been subscribed toward the building of a steamer to ply between Swansborough and New Berne.

The tons of freight transported during the year are estimated at 18,165, an increase of 6,168 tons over the previous years.

Very respectfully, your obedient servant,

E. D. THOMPSON,
Assistant Engineer.

Capt. W. H. BIXBY,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

When placed under governmental improvement in 1886, this water-way possessed an 8-inch depth of channel at dead low water from Beaufort to the town of Swansborough on White Oak River. Its commerce is estimated to have then been about $200,000 per year, carried in sail-boats of less than 2 feet draugh, using the route during high water. At present the entire channel has been deepened to a depth of about 2 feet at dead low water, and a depth of 3 feet at average water.

The improvement has not yet progressed sufficiently to allow any considerable increase of traffic, as a large portion of the channel still remains to be dredged to the full 3 feet depth, and the rates of frieght remain about the same as before.

The present commerce is estimated to be about $418,400 of goods transported per year.

During 1887, under the stimulus of the improvement, saw-mills having a capacity of 50,000 feet of lumber per day were erected on the White Oak River and the lumber industry will add from $150,000 to $200,000 annually to the commerce of this water-way.

A small steam-boat has been plying over the route during the year, and a company has been formed to construct another boat to ply over the route between Swansborough and New Berne, *via* Morehead City and Beaufort, N. C.

In addition to its local importance, this route is a continuation of the inland navigation from the Chesapeake to New River, and is valuable as a link in that system.

The commerce for the year ending December 31, 1889, is estimated as follows:

Class of goods.	Exports.	Imports.	Total.
Cotton and products	$34,000	.....	$34,000
Tobacco	.....	$5,000	5,000
Rice	5,000	.....	5,000
Grains and forage	2,000	.....	2,000
Vegetables and truck	43,000	.....	43,000
Live stock and products	7,400	6.000	13,400
Fish, oysters, etc	33,500	.....	33,500
Naval stores	17,000	.....	17,000
Lumber and products	80,000	.....	80,000
Fertilizers	.....	1,000	1,000
Machinery	.....	5,000	5,000
General merchandise	.....	177,500	177,500
Sundries	2,000	.....	2,000
Total	223,900	194,500	418,400

Total tonnage, 18,165 tons. Gain during year, 6,168 tons.

No new transportation lines established.

The above statistics are based mainly upon the reports of Assistant Engineer E. D. Thompson, made after much correspondence and conversation with steam-boat captains and agents, custom-house officials, and prominent shippers and merchants.

The commerce at present, as above shown, is about 18,165 tons	$418,400
The commerce before the improvement began was	200,000
The development of commerce since beginning of improvement is	218,400
Expended on improvement up to December 31, 1889	14,624
The development of annual commerce for every dollar spent on the improvement since its commencement is about	15

M 9.

IMPROVEMENT OF NEW RIVER, NORTH CAROLINA.

HISTORY OF OPERATIONS.

(1) *Reference to past reports.*—For special description of this river, see pages 1117–1118, Annual Report for 1882; for map and special history of past work, see pages 992 and 994, Annual Report for 1886.

(2) *Original condition.*—The New River, emptying directly into the Atlantic Ocean between Beaufort Harbor and Wilmington, N. C., has a total length of about 52 miles and a drainage area of 492 square miles. Its lower 21 miles, from its mouth to Jacksonville, forms a fine basin of brackish water of from 500 to 10,000 feet width and of at least 5 feet channel depth, with 20,000 acres of oyster farms, and with rich agricultural surroundings. When placed under Governmental improvement in 1882 this river had very poor facilities for transporting goods to market. Its communication with the ocean was blocked by an oyster-rock barricade, through which there existed only a long and very crooked channel of 50 feet width and 3 feet depth at low water. Its commerce, limited to wagons and small boats, is now estimated to have then been about $200,000 of goods per year.

(3) *Plan of improvement.*—The original project of 1882 proposed to secure a 150-foot channel, 5 feet deep at low water, from the upper river to the ocean, by dredging the old channel to its full size through about 7,000 feet of this oyster-rock barricade. A personal examination of the locality in 1885 showed the agricultural richness of the river basin, its pressing need for better transportation facilities, and the worthiness of the improvement.

The total final cost of this work was estimated in 1885 to be $40,000. Inadequate yearly appropriations and their consequences (the alternate disorganization and reorganization of working parties, damage to unfinished work, extra superintendence, and deterioration of plant) may add considerably to this final cost.

The aggregate amount appropriated for this project up to June 30, 1890, is $23,000.

(4) *Results.*—Up to June 30, 1889,a total of $18,532.49 had been spent in all upon this improvement, replacing the long and crooked channel by a shorter and straighter channel of at least 40 feet bottom width and 3 to 5 (average 4.5) feet depth at low water.

This new channel was already in daily use by the craft entering New River from the ocean, and was steadily deepening under the scour of the river and tidal currents. The improvement was too recent to then show any marked increase in the commerce of the river.

The navigation was not obstructed by any bridges below its present head at Jacksonville.

(5) *Work of past year.*—The special work of the past year is as follows: Expenditures, $655.69; value of United States plant, $265.

No work of dredging was done during the year, because the available funds were insufficient for advantageous use.

Owing to its variable features and the difficulty of properly specifying it beforehand, all minor work was, for advantage and economy, allowably done by hired labor and the purchase of materials in open market.

During the month of June, 1890, some minor surveys were made by Assistant Engineer E. D. Thompson to determine the effect of past work and to serve as a basis for future operations.

A detailed survey was made from Cedar Bush Marsh to the Ocean Bar. At Cedar Bush Marsh the depth in the lower portion of the cut has been maintained, and is now from 4 to 5 feet at low water, but the upper portion of the half-finished channel has shoaled to such an extent (to 2½ feet at low water) that vessels are unable to use it at present.

At Wright's Island the cut has now markedly widened and scoured to an average depth of 8 to 10 feet at low water, and the shoals at both ends are rapidly scouring, so that 5 feet at low water can now be carried through the cut.

The present least low-water depth on the bar is 3 feet.

Cedar Point Creek, just below the south mouth of Cedar Bush Marsh Cut, is being closed by an oyster-shell dike 500 feet long, to rise to half tide. This work is still in progress.

A survey, based on compass-directions and eye-measured distances, was made from Bluff Point to Jacksonville, about 21 miles.

In December, 1888, when new appropriations became available bids were solicited by public advertisement for the dredging, much needed at this place, but the available funds were too small to tempt any contractor to undertake the work, and were also too small to allow of advantageous work by the United States.

Inspections of the locality were made during the year.

The ocean bar entrance, which now has a least depth of 3 feet at low water, appears to be in as permanent and useful condition as at any time during the past six years.

The work of this improvement during the year has been under the immediate supervision of Assistant Engineer E. D. Thompson, whose report is herewith appended.

Since but little new work has been done during the past year and

the past work is in a half-finished condition, the general situation remains about the same as at the commencement of the fiscal year.

The latest commercial statistics, those of the calendar year ending December 31, 1889, are herewith appended, showing a total commerce of about 14,162 tons.

(6) *Recommendations for future work.*—It is recommended that the present adopted project be completed so as to secure a channel of from 100 to 150 feet in width, and 5-foot depth, at low water, from the ocean up to the upper river at a total expense of $17,000 in addition to the funds available June 30, 1890, to be appropriated in a single amount within the next year. Smaller yearly appropriations and their consequences, the alternate disorganization and reorganization of working parties, damage to unfinished work, extra superintendence, and deterioration of plant, may increase the cost of the work by about $2,000 per appropriation. Further improvement so as to give a channel of greater depth or width is not recommended at present.

This improvement, once thoroughly completed, should be permanent.

This river is in the collection district of Beaufort, N. C.

Money statement.

July 1, 1889, amount available		$4,467.51
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$213.82	
July 1, 1890, outstanding liabilities	441.87	
		655.69
July 1, 1890, balance available		3,811.82
Amount appropriated by act of September 19, 1890		5,000.00
Amount available for fiscal year ending June 30, 1891		8,811.82
Amount (estimated) required for completion of existing project		12,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		12,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

REPORT OF MR. E. D. THOMPSON, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
June 30, 1890.

CAPTAIN: I have the honor to submit the following report of operations for the fiscal year ending June 30, 1890, on the improvement of New River, North Carolina.

No dredging was done during the year, as the amount available was so small that no contractor could be found willing to assume the risks of carrying his plant to New River.

Detailed examinations and surveys of the condition of past work were made in June, 1890.

At Wright's Island, the cut has deepened somewhat (the average depth of water now being 8 to 10 feet at low water), and the shoals at both ends have scoured, so that 5 feet at low water can be easily carried through the cut from the bar; this cut is steadily improving.

At Cedar Bush Marsh, the cut (which has not yet been finished to more than half width) still has an average depth of 4 to 5 feet at low water, but the upper portion has now shoaled to such an extent (2½ feet at low water) that vessels are unable to use it; the fill occurs in that portion of the unfinished cut where the outlet sloughs are not closed by dumpage. At the south end of the cut the small shoal remains about the same as last year.

The least soundings on the bar at low water were 3 feet. The bar is in a shifty condition and it seems probable from its present appearance that it will soon change to a position more favorable to navigation.

In June, 1890, a rapid minor survey, based on pocket-compass directions and eye-measured distances, was made from Bluff Point to Jacksonville, about 21 miles

Work on a small oyster-shell dike, 500 feet long, to close Cedar Point Creek, just below the southern mouth of Cedar Bush Marsh Cut, was commenced in June, 1890, and is still in progress; this dike will rise to half-tide and is designed to confine more of the flood tide to the Cedar Bush Marsh Cut.

The principal impediments to navigation are, as stated in last year's reports, the shoals at both ends of the unfinished Cedar Bush Marsh Cut, and a few oyster rocks in the open river above the cut.

The widening and deepening of the Cedar Bush Marsh Cut, including the closing of outlet sloughs with dumpage, now seem essential to the maintenance of good navigation from the open river to the bar.

No new lines of navigation have been established during the year; the tons of freight carried in 1889 are estimated at 14,162, an increase of 578 tons over the calendar year of 1888.

The expenses of the year have been as follows:

For purchase of plant	$67.02
For superintendence and surveys	200.32
For general work	369.28
Total	636.62

Very respectfully, your obedient servant,

E. D. THOMPSON,
Assistant Engineer.

Capt. W. H. BIXBY,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

The amount of commerce previous to the commencement of work in 1882 is estimated to have been about $200,000.

The present commerce going out over New River Bar is estimated at at least $700,000. It is carried on by sailing vessels with the ports of Baltimore, Philadelphia, Wilmington, Charleston, Beaufort, and New Berne, principally.

Rates of freight have decreased 15 to 20 per cent. since 1882, and insurance is seldom asked.

Each dollar so far spent upon this improvement has been accompanied by the development of $29 of annual commerce.

The overland commerce, especially of oysters to Wilmington, is quite large. The completion of the improvement will give a nearly straight channel from 110 to 150 feet wide and of at least 5 feet depth at low water through the marshes from the open water of the river direct to the ocean. The drawback to navigation during past years has been the uncertain condition of the bar, but its present condition promises better for the future. The bar improvement with a straight channel will afford easy access to a section the resources of which, particularly in lumber and timber, have been but little developed. The manufacture of lumber should become a leading industry and add $150,000 to $200,000 to the annual commerce. To the residents of this section the river is the only means by which their products can be carried to a profitable market without large expense.

The commerce for the year ending December 31, 1889, is estimated as follows:

Class of goods.	Exports.	Imports.	Total.
Cotton and products	$113,400	.....	$113,400
Tobacco	.....	$15,000	15,000
Rice	400	.....	400
Grains and forage	12,000	.....	12,000
Vegetables and truck	20,400	.....	20,400
Live stock and products	7,950	115,000	122,950
Fish, oysters, etc	163,000	.....	163,000
Naval stores	83,000	.....	83,000
Lumber and products	25,500	.....	25,500
Fertilizers	.....	900	900
General merchandise	.....	175,000	175,000
Total	425,650	305,900	731.550

Approximate tonnage, 14 162 tons.
No new transportation lines established.

PROGRESS MAP FOR 1890.

NEW RIVER, N.C.

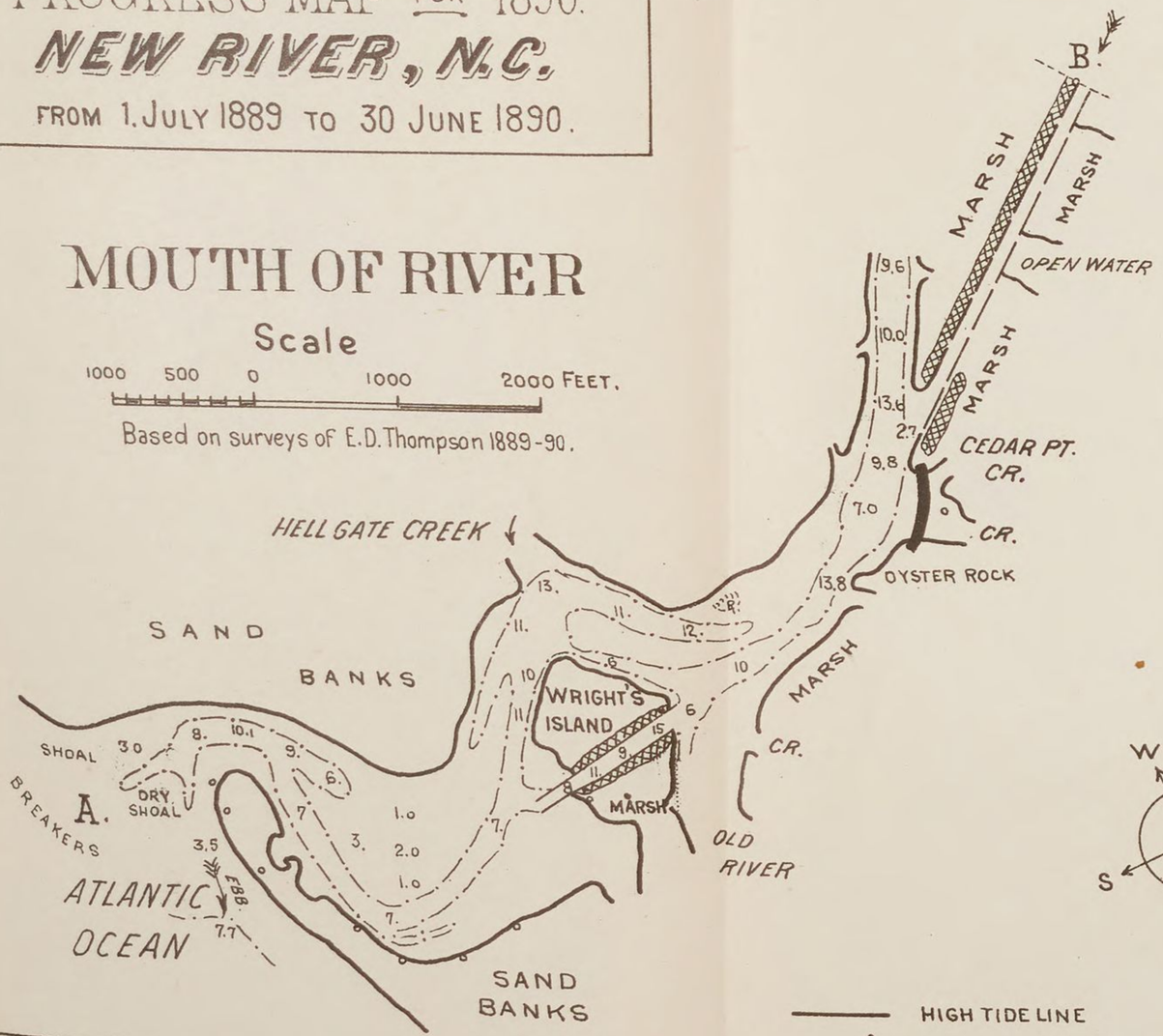
FROM 1. JULY 1889 TO 30 JUNE 1890.

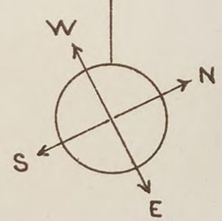
MOUTH OF RIVER

Scale

1000 500 0 1000 2000 FEET.

Based on surveys of E.D. Thompson 1889-90.





HIGH TIDE LINE

5 FT. CONTOUR BELOW LOW WATER

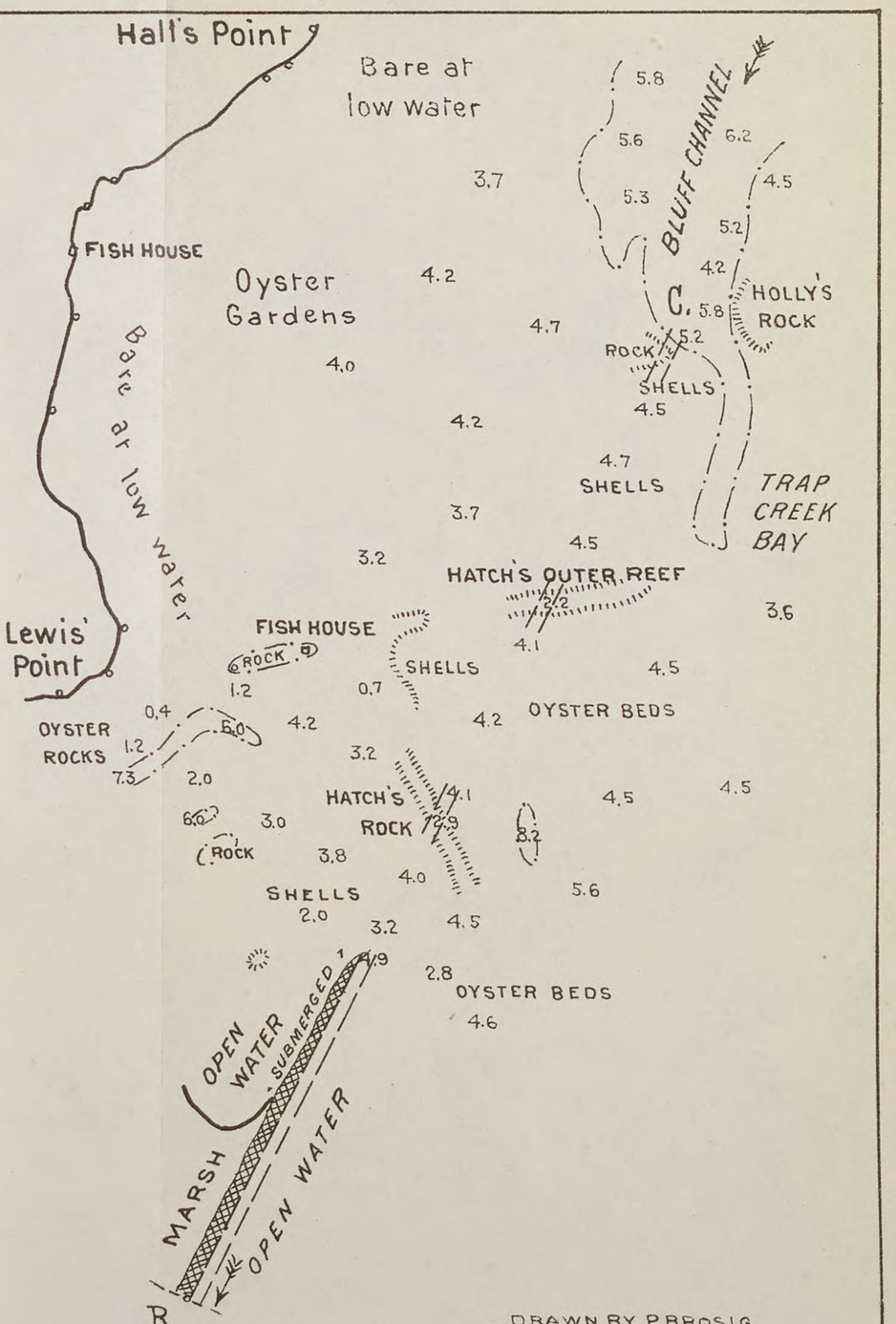
SURVEY STAKES

OYSTER ROCKS, SUBMERGED

DREDGING

DUMPAGE OF 1887/88.

JETTIES OF 1890



DRAWN BY P. BROSIG.

Wilmington, N.C. *July 1890.*

Respectfully submitted

W. H. C. Bixby

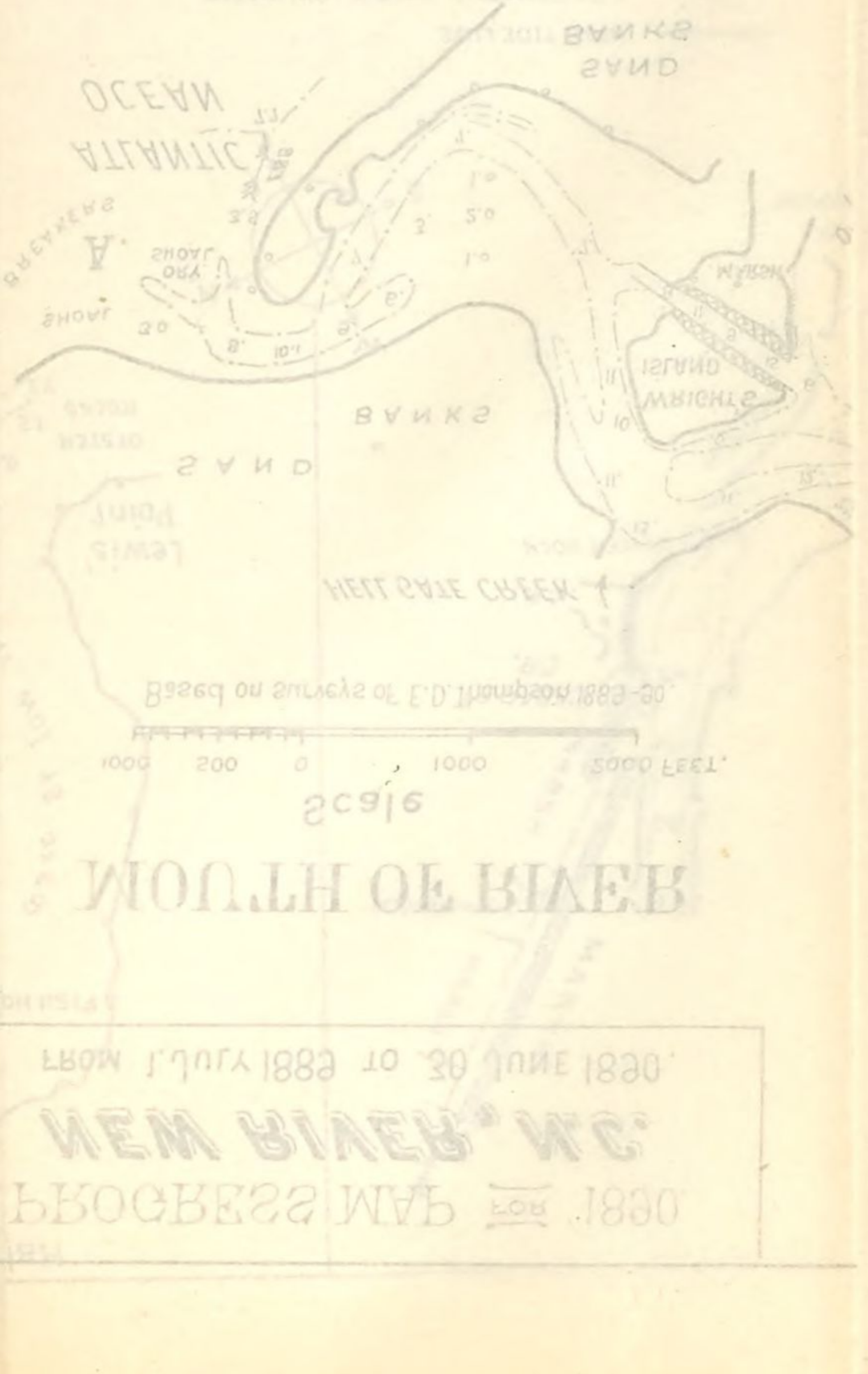
CAPTAIN OF ENGINEERS

MOUTH OF RIVER

PROGRESS MAP FOR 1890

NEW RIVER, N.C.

FROM JULY 1889 TO 30 JUNE 1890.



Based on surveys of L.D. Thompson 1889-90.

Scale

1000 200 0 1000 5000 FEET.

CAPTAIN OF ENGINEERS

Approved July 1890

Washington D.C.

The above statistics are based mainly upon the reports of Assistant Engineer E. D. Thompson, made after much correspondence and conversation with steam-boat captains and agents, custom-house officials, and prominent shippers and merchants.

The commerce at present as above shown is 14,162 tons	$731,550
The commerce before the improvement began was	200,000
The development of commerce since beginning of improvement is	531,550
Expended on improvement up to December 31, 1889	18,608
The development of annual commerce for every dollar spent on the improvement is	29

M 10.

IMPROVEMENT OF BLACK RIVER, NORTH CAROLINA.

HISTORY OF OPERATIONS.

(1) *Reference to past reports.*—For special description of river and obstructions, see pages 1145–1154, Annual Report for 1885.

(2) *Original condition* —The Black River, North Carolina, a tributary of the Cape Fear River, has (with its own main tributary South River) a total length of about 175 miles and a drainage area of about 1,547 square miles.

When placed under governmental improvement in 1886, this stream possessed a moderately well cleared channel from its mouth (in the Cape Fear River, 14 miles above Wilmington) 22 miles upwards to Point Caswell, with 2.5 foot depth at low water and 4-foot depth at high tide; thence a roughly cleared navigation 48 miles farther to near Lisbon, with 2.5 feet depth during nine months per year and with 6 feet depth during six months per year. A steamer of 2.5-foot draught was regularly running once or twice per week all the year to Point Caswell and nine months per year to Clear Run (about 7 miles below Lisbon). The commerce (including rafted goods) is estimated to have been $750,000 per year.

(3) *Plan of improvement.*—The original project of 1885 as continued to date proposed to secure a thoroughly cleared channel of natural depth over the 70 miles of river from its mouth to near Lisbon, and afterwards a 4-foot channel at low water below Point Caswell.

The total final cost of this work was estimated in 1885 at $33,500. Inadequate yearly appropriations and their consequences (the alternate disorganization and reorganization of working parties, damage to unfinished work, extra superintendence, and deterioriation of plant) may add considerably to this final cost.

The aggregate amount appropriated for this project, up to June 30, 1890, is $3,000.

(4) *Results.*—Up to June 30, 1889, a total of $2,377.24 had been spent in all upon this improvement, in the removal of the worst obstructions over the entire river. All private claims to the exclusive navigation of this river had been annulled by the State of North Carolina. In consequence of this work, steam-boats had been enabled to run with increased certainty and regularity. The commerce was then about $1,200,000 of transported goods per year, showing that each dollar spent upon this improvement, since its commencement, has been accompanied by the development of about $140 of annual commerce. The navigation was not obstructed by bridges without draws.

(5) *Work of the past year.*—The special work of the past year is as follows: Expenditures, $519.61; value of United States plant $40.

The available funds were entirely insufficient for effective work on this river, and work was mainly confined to office duties and minor field work. A small reserve fund was retained for use in emergencies and for incidental work.

Owing to the variable nature of the work, the difficulty of specifying it beforehand and of measuring it afterwards, the work was, for advantage and economy, allowably done by hired labor and the purchase of materials in open market.

Inspections of work and property were made during the year.

Many bad obstructions having been reported in July as existing all along the river, a small force was put to work in August and September and the worst of these obstructions were removed, so as to leave the river channel fairly well cleared for its present steam-boat navigation.

From the channel there were removed 3 logs, 18 trees, 4 stumps and 6 old bridge piles; from the banks there were cut and pulled back 155 overhanging trees and 573 cords of brush.

A minor survey was made at the crossing of the Cape Fear and Yadkin Valley Railroad, to see that the railroad company had constructed the bridge according to the proposed specifications and in such a manner as not to obstruct navigation.

Water-guages were established in November at four points on the river and have been kept continuously ever since.

Although the small amount of work that could be done during the year was of considerable benefit to navigation, yet the river is far from being properly cleared, and there is an urgent need for more work to put the stream in thoroughly good order.

The latest reliable commercial statistics, those for the year ending December 31, 1889, are herewith appended, showing a present annual commerce of $1,180,000 (about 76,638 tons).

(6) *Recommendations for future work.*—It is recommended: That this improvement be completed so as to secure, first, a fairly cleared natural channel over the entire river from its mouth up 70 miles to near Lisbon, then a 4 foot channel below Point Caswell, and then an improved channel through the narrows, at a total expense of $30,500 in addition to the funds available on June 30, 1890; this amount to be appropriated in yearly installments of as much as $20,000 each until complete. Smaller yearly appropriations will involve the alternate disorganization and reorganization of working parties, damage to unfinished work, extra superintendence, deterioration of plant, and may increase the expense from $2,000 to $4,000 per appropriation. Further improvement so as to secure a 6-foot depth of channel below Point Caswell is not recommended at present.

After this improvement is finished its proper maintenance may cost from $1,000 to $3,000 per year.

The river is in the collection district of Wilmington, N. C.

Money statement.

July 1, 1889, amount available		$622.76
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$501.28	
July 1, 1890, outstanding liabilities	18.33	
		519.61
July 1, 1890, balance available		103.15
Amount (estimated) required for completion of existing project		30,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		20,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. CHAS. HUMPHREYS, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Kinston, N. C., June 16, 1890.

CAPTAIN: I have the honor to make the following report on Black River, North Carolina, for the fiscal year ending June 30, 1890:

Owing to the small amount of funds available, the operations have been confined to cross-sectioning the river at Point Caswell, Mill Creek Landing, Hampton, and Clear Run; erecting gauges at these points, and keeping a continuous gauge record since December 1, 1889.

Navigation has been closed a considerable part of the year on account of low water, and logs and other obstructions waiting removal, so that a good deal of the country produce has been hauled in wagons to the nearest railroads.

* * * * * * *

Value of United States plant, $30. It is in good order.

Very respectfully, your obedient servant,

CHAS. HUMPHREYS,
Assistant Engineer.

Capt. W. H. BIXBY,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

When work was commenced, in 1885, for this improvement the river was navigable for narrow 2.5-foot draught steamers all the year 22 miles to Point Caswell, and nine months of the year 41½ miles further to Clear Run, within 7 miles of Lisbon, the head of the river. One steamer ran regularly over the route. The commerce is estimated to have been then about $750,000 per year.

The rates of freight and insurance have not as yet been appreciably affected by the improvement.

The commerce of the river basin is about the same as in 1885, but a greater proportion of it now goes by steamers than at that time.

The present river commerce is now estimated at least $1,180,000. The small amount of funds so far spent have been of great value to the river navigation, and a few thousand dollars more at the present moment would be also of very great immediate advantage to navigation.

There are now two steamers of 2.5 to 3.5 feet draught, 60 tons capacity, making semi-weekly trips to Clear Run for nine to ten months per year, and one steam-flat, 40 tons capacity, making tri-weekly trips to Point Caswell; and about 20 flats of 30 to 40 tons capacity each are towed irregularly a part of the year to Point Caswell by 1 launch. No great increase of commerce is expected until the improvement above Point Caswell is completed. This river is the main and natural outlet of Samson County. Its improvement will place much good land in good communication with a market, and should add $500,000 to its commerce.

The commerce for the year ending December 31, 1889, is estimated as follows:

Class of goods.	Exports.	Imports.	Total.
Cotton and products	$30, 200	.....	$30, 200
Tobacco	.....	$10, 000	10, 000
Rice	10, 000	9, 000	19, 000
Grains and forage	.....	8, 500	8, 500
Vegetables and truck	8, 000	.....	8, 000
Live stock and products	21, 800	36, 000	57, 800
Fish, oysters, etc	.....	900	900
Naval stores	645, 000	.....	645, 000
Lumber and products	166, 643	.....	166, 643
Fertilizers	.....	3, 000	3, 000
Machinery	.....	5, 000	5, 000
General merchandise	.....	226, 500	226, 500
Sundries	1, 400	.....	1, 400
Total	883, 043	298, 900	1, 181, 943

Total tonnage, 76,638 tons.

No new transportation lines established.

The above statistics are based mainly upon the reports of Assistant Engineer Charles Humphreys, made after much correspondence and conversation with steamboat captains and agents, custom-house officials, and prominent shippers and merchants.

The commerce at present, as above shown, is about 75,638 tons	$1,181,943
The commerce before the improvement began was	750,000
The development of commerce since beginning of improvement is	432,043
Expended on improvement up to December 31, 1889	3,000
The development of annual commerce for every dollar spent on the improvement since its commencement is about	140

M 11.

IMPROVEMENT OF CAPE FEAR RIVER, ABOVE WILMINGTON, NORTH CAROLINA.

HISTORY OF OPERATIONS.

(1) *Reference to past reports.*—For special description of river, see pages 742–749, Annual Report for 1872; for list of present shoals and obstructions, see pages 999, 1000, Annual Report of 1886; for map of river and jetties, see page 1086, Report of Chief of Engineers for 1889.

(2) *Original condition.*—The Cape Fear River, above Wilmington, has a total length of about 400 miles and a drainage area of 7,167 square miles; of which 5,620 square miles lie above the mouth of the Black River, its main tributary. At Fayetteville, the present head of navigation, 115 miles above Wilmington, the river varies from 112 feet breadth, 16 inches average depth, 150 square feet cross-section, 1 mile per hour current, and 200 cubic feet discharge per second in extreme droughts, up to 1,400 feet breadth, 50 feet maximum depth, 7 miles per hour velocity, and 350,000 cubic feet discharge per second in high freshets. Ordinary low water usually lasts from one to four months per year, and 15-foot stages of water at Fayetteville are usually reached once a month during the rest of the year.

When placed under governmental improvement, in 1881, this stream was navigable during the nine flush-water months of the year from Wilmington, 115 miles upward to Fayetteville; but the channel for the upper 75 miles was badly obstructed by sunken logs, snags, overhanging trees, and shoals; and for the upper 66 miles it was full of shoals on which there was not more than 12 to 14 inches of water during the low-water season. At that time the navigation was owned by private parties. Its commerce is estimated to have then been about $800,000 of goods transported per year.

(3) *Plan of improvement.*—The original project of 1881–'82, as continued to date, proposed to buy out the private owners of the river, then to clear out its natural obstructions, and to further provide a continuous channel over its upper 66 miles by dredging, and by artificially contracting its water-way by jetties through at least thirty-two shoals.

The total final cost of this work was estimated in 1885 at $480,000 for a 3-foot actual channel depth during eleven or twelve months of the year up to Fayetteville. There appears every probability that this expenditure will finally give the expected improvement, and that the commerce will be increased by that time to $4,000,000 of goods per year.

The aggregate amount appropriated for this work up to June 30, 1889, is $88,250.

(4) *Results.*—Up to June 30, 1889, a total of $83,332.31 had been spent in all upon this improvement, giving a moderately well cleared channel over the whole length of river, a moderately good continuous 4-foot channel at least 100 feet wide during the entire year from Wilmington 46 miles to Kelly's Cove thence a similar 3-foot channel 27 miles farther to Elizabethtown (a place of considerable commerce), and thence a 2-foot channel at least 80 feet wide 42 miles farther to Fayetteville during eleventh months of the year, increased to 5-foot draught from Wilmington to Fayetteville during nine months of the year.

In consequence, three permanently-established steam-boat lines had been running over the entire distance with full draught for nine months each year, and with lessened draught the rest of the time. The commerce during these years has increased about $200,000 per year; had been further benefited by exemption from tolls, and was then about $2,700,000 of transported goods per year, showing that each dollar once spent on this improvement had been accompanied by the development of about $26 of annual commerce.

The navigation of this stream was not obstructed by bridges without draws between Wilmington and Fayetteville.

(5) *Work of the past year.*—The special work of the past year is as follows: Expenditures, $4,638.95; value of United States plant, $5,380.

During the working season one steam launch and hoister, two stone flats, and other plant were employed on the river.

Owing to its varied features and the difficulty of specifying it beforehand and measuring it afterwards, the work was, for advantage and economy, allowably done by hired labor and the purchase of materials in open market.

During the months of July and August there were quarried 620 cubic yards of stone from Walker's Bluff, about 53 miles above Wilmington; from McArthur's, about 6 miles above Fayetteville, and from Red Rock, about 25 miles above Fayetteville.

Of this stone, 123 cubic yards were towed to and deposited at McRae's Cross, 5 miles below Fayetteville, and 140 cubic yards were towed to and deposited at Thames Shoal, 13 miles below Fayetteville.

During August and September the plant worked over the entire length of the river under improvement (115 miles from Fayetteville to Wilmington) removing from the banks 222 leaning trees (cut and pulled back), 106 cords of brush (cut and trimmed); from the channel, 111 logs and 73 stumps.

During October, at various shoals in the upper river, 657 cubic yards of stone and 245 cords of brush were built into 7 jetties (620 linear feet) as follows: At McRae's Cross Shoal, 5 miles below Fayetteville, 1 jetty; at Thames Shoal, 13 miles below Fayetteville, 2 jetties; at Morehead Shoal, 36 miles below Fayetteville, 4 jetties.

During the entire working season work was greatly interfered with by unusually high freshets.

Owing to the excessively high water and the near exhaustion of funds all work in the field was stopped on October 31, and the plant was moved to Wilmington and there laid up to await the next low-water season and new appropriations.

During the remainder of the year work has been confined to office duties and minor work.

A new cylinder and shaft were built into the steam launch *H. G. Wright.*

Water guages were kept at one or two places during the year.

Inspections of plant and work were made during the year.

The work of this improvement has been well and vigorously prosecuted under the immediate supervision of Assistant Engineer Chas. Humphreys, whose report is herewith appended.

The work of the past year has maintained the existing fair navigable condition of the river. The effect of the jetties so far constructed has been to better the channel at all formerly worst places, so that now low-water navigation is possible during fully eleven months of the year.

The bridge of the Cape Fear and Yadkin Valley Railroad at Fayetteville (mentioned in Appendix M II, Annual Report of Chief of Engineers for 1889) has been completed and been built in such a way as not to interfere with navigation. Otherwise the general situation is about the same as at the beginning of the fiscal year.

The latest reliable commercial statistics, those for the year ending December 31, 1889, are herewith appended, showing a commerce of $2,518,035 per year, about 150,000 tons.

(6) *Recommendations for future work.*—Were the commerce of the river sufficiently large to justify the expenditure of such an amount, in my opinion the proper method of improving this river would be by the construction of suitable dams and locks of 32 feet total lift, giving a 6-foot navigation at all times of the year to Fayetteville, at a total approximate cost of $1,200,000. A commerce sufficient to justify such an expenditure can not be expected from this locality for many years. Consequently the lock-and-dam navigation must be postponed for the present, and a contracted river channel must be accepted as the best under the circumstances.

It is recommended, therefore, that this improvement be completed in accordance with the present approved and adopted project, so as to secure a thoroughly cleared 4-foot channel from Wilmington to Elizabethtown; thence a similar 3-foot channel to Fayetteville during eleven or twelve months of the year. at a total expense of $391,750 in addition to the funds available June 30, 1889; this amount to be appropriated in yearly installments of as much as $120,000 until complete. Smaller yearly appropriations, involving the alternate disorganization and reorganization of working parties, damage to unfinished work, deterioration of plant, and extra superintendence may increase the cost of the work from $1,000 to $4,000 per appropriation. Further improvement, so as to extend the navigation above Fayetteville, or so as to increase the depth below Fayetteville, is not recommended.

After this improvement is completed its proper maintenance may cost from $1,000 to $3,000 per year.

This river is in the collection district of Wilmington, N. C.

Money statement.

July 1, 1889, amount available		$4,917.69
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$4,558.49	
July 1, 1890, outstanding liabilities	80.46	
		4,638.95
July 1, 1890, balance available		278.74
Amount appropriated by act of September 19, 1890		15,000.00
Amount available for fiscal year ending June 30, 1891		15,278.74
Amount (estimated) required for completion of existing project		376,750.00
Amount that can be profitably expended in fiscal year ending June 30, 1892,		120,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

PROGRESS MAP FOR 1890

CAPE FEAR RIVER ABOVE WILMINGTON, N.C.

FROM 1. JULY 1889 TO 30. JUNE 1890.

JETTIES

SCALE

0 200 400 600 800 1000 1200 1400 1600 1800 2000 FEET

——— = SHORE LINE

—·— = 3 FT. DEPTH AT LOW WATER

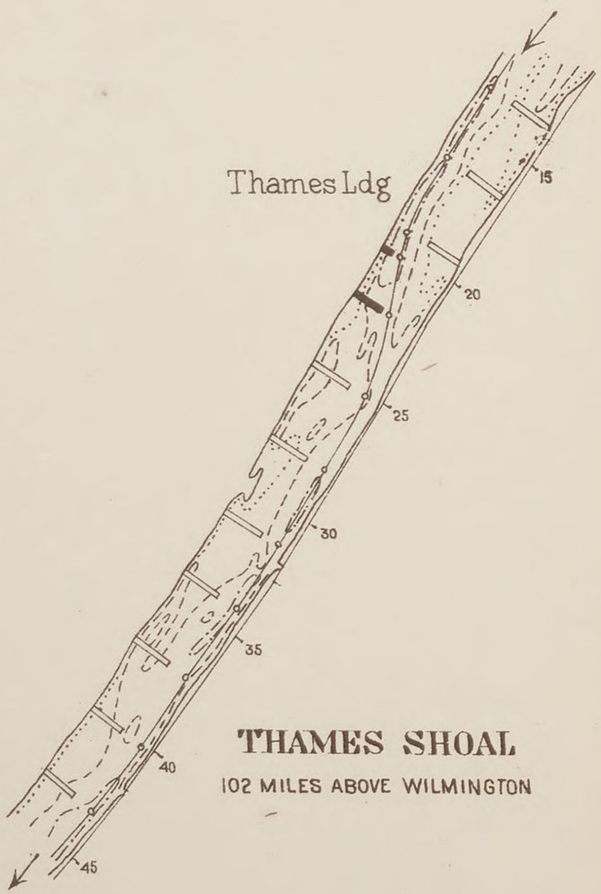
25 = SURVEY LINE AND STATIONS

—o— = CENTER OF PROPOSED CHANNEL

▭ = JETTIES BUILT OR PROPOSED

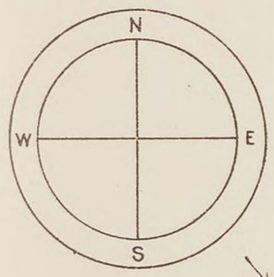
▬ = WORK DONE DURING FISCAL YEAR 1889-90.

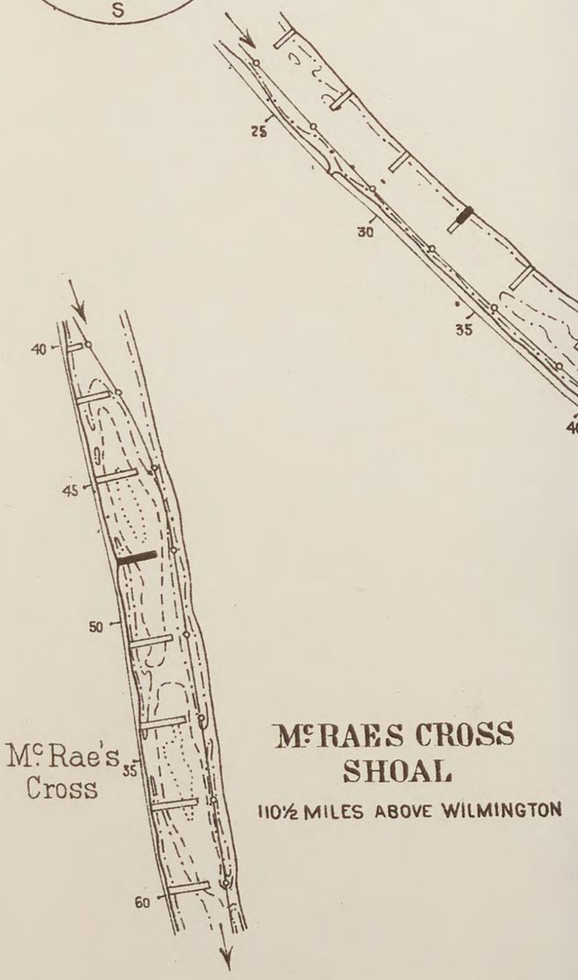
BASED ON SURVEYS OF CHAS. HUMPHREYS 1885-88, UNDER DIRECTION OF CAPT. W. H. BIXBY, CORPS OF ENGRS.



THAMES SHOAL

102 MILES ABOVE WILMINGTON





Mc RAES CROSS SHOAL

110½ MILES ABOVE WILMINGTON

MOREHEAD SHOAL

78 MILES ABOVE WILMINGTON

Wilmington, N.C. July 1890

Respectfully submitted

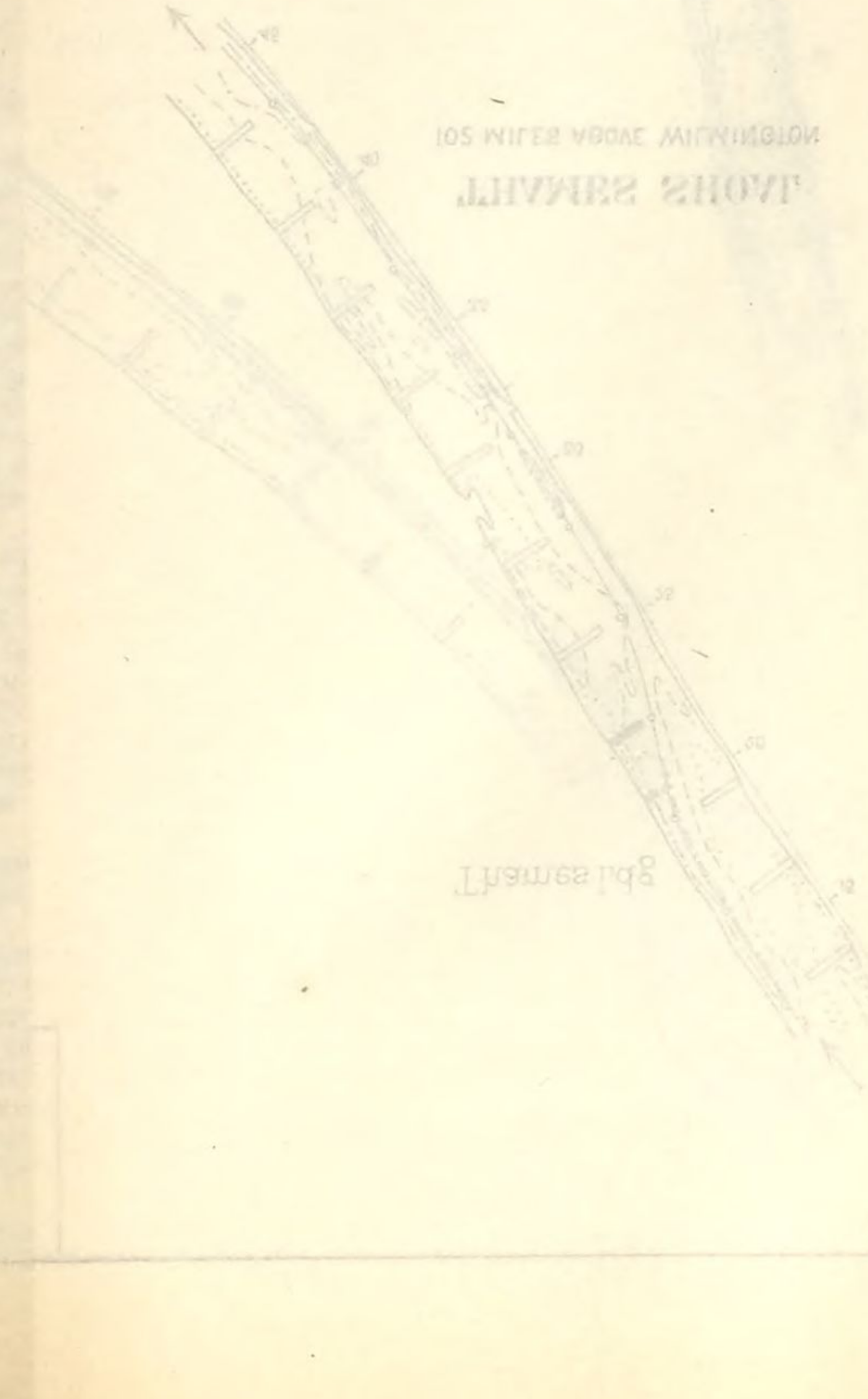
Wm H Bixby

CAPTAIN OF ENGINEERS

DRAWN BY P. BROSIG.

CAPTAIN OF ENGINEERS

Respectfully submitted



REPORT OF MR. CHAS. HUMPHREYS, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Kinston, N. C., June 16, 1890.

CAPTAIN: I have the honor to submit the following report on the improvement of the Cape Fear River, North Carolina, above Wilmington, for the fiscal year ending June 30, 1890.

The operations for the past year have been as follows:

From July 1 to August 10, quarried 620 cubic yards of rock; from August 10 to 19, towed 140 cubic yards rock to Thames Shoal, and 123 cubic yards to McRae's Cross for future construction of jetties; also fitted up hoister for snagging. From August 19 to 31 (the river being still too high to jetty or log), cut down and hauled back 188 leaning trees and 71 cords of brush. From August 31 to September 18, watching the plant while waiting for low water. From September 18 to 27, snagged the river from Fayetteville to Wilmington, removing 111 logs and 73 stumps from channel, trimming 34 trees and cutting 35 cords of brush on the banks, after which the hoister was cleaned and tied up in Wilmington. From October 2 to 27, built rock jetties with brush foundation at McRae's, 5 miles below Fayetteville, station 47+90, west bank, 140 feet long; at Thames, 13 miles below Fayettville, station 20+30, west bank, 40 feet long; and at station 22+18, west bank, 100 feet long; at Morehead, 36 miles below Fayetteville, station 32+30, east bank, 50 feet long, at station 56+50, east bank, 140 feet long, at station 57+40, west bank, 40 feet loug, at station 59+40, west bank, 110 feet long. October 27 the launch and flats were tied up in Wilmington at United States wharf for want of funds. Since then J. W. Johnson, the contractor, has put an additional engine in the launch, and by hired labor the boat has been calked, painted, and the wood-work generally repaired.

The work throughout the whole season has been greatly impeded by high water.

* * * * * * *

During the past year there were plying on this river 3 stern-wheel steamers, 4 tug-boats, and 41 flats.

The Cape Fear and Yadkin Valley Railroad, completed this year from Fayetteville to Wilmington, now carries much freight formerly carried by boat only.

Very respectfully, your obedient servant,

CHAS. HUMPHREYS,
Assistant Engineer.

Capt. W. H. BIXBY,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

When work commenced, in 1881, the river was badly obstructed and only navigable nine months of the year, and the navigation was owned by a private corporation. The commerce is estimated to have then been about $800,000 per year. At present the river is fairly well cleared of obstructions (logs, trees, etc.), is navigable all the year for light-draught boats, and for 5-foot draught steamers during at least eleven months of the year. Steamers now run regularly and daily. The commerce is now about $2,520,000 per year, and with Black River commerce (which also goes over part of this river) is about $3,500,000 per year. The commerce of the Cape Fear River above Wilmington is carried by steamers and flats as follows: The *Murchison*, of about 150 tons capacity; *Cape Fear*, 150 tons, and the *Hurt*, 90 tons. These steamers have each two 150-ton flats, and there are about thirteen other flats on the river averaging about 60 tons capacity each. The steam-tugs *Marie*, *Pet*, *Lawrence*, and launches *Navassa* and *Alberta*, are employed a part of the year in towing.

The rates of freight have been reduced about 33 per cent., and river insurance is regarded as unnecessary except against fire.

The commerce has increased over $200,000 per year on an average ever since work began, in 1881. Every dollar spent so far upon the improvement has been accompanied by the development of about $20 of annual commerce. In addition to this the former tolls have been removed. There is every indication that with a never-failing depth of 3 feet throughout the entire year the commerce would gradually increase to $4,000,000 or more per year, including rafted goods.

The partial failure of the cotton crop has caused a falling off of the commerce as compared with the preceding year.

The commerce for the year ending December 31, 1889, is estimated as follows:

Class of goods.	Exports.	Imports.	Total.
Cotton and products	$400,000	$14,000	$414,000
Tobacco	12,950	24,000	36,950
Rice	18,642	14,913	33,555
Grains and forage	2,000	21,000	23,000
Vegetables and truck	11,076	.....	11,016
Live-stock and products	38,000	150,000	188,000
Fish, oysters, etc	20	4,500	4,520
Naval stores	550,000	.....	550,000
Lumber and products	204,492	.....	204,492
Fertilizers	.....	300,000	300,000
Machinery	39,534	.....	39,534
General merchandise	64,169	530,000	594,169
Sundries	5,218	113,531	118,749
Total	1,346,101	1,171,944	2,518,045

Total tonnage, 150,000 tons.

No new transportation established.

The above statistics are based mainly upon the reports of Assistant Engineer Charles Humphreys, made after much correspondence and conversation with steamboat captains and agents, custom-house officials, and prominent shippers and merchants.

The commence at present, as above shown, is	$2,518,045
The commerce before the improvement began was	800,000
The development of commerce since beginning of improvement is	1,718,035
Expended on improvement up to December 31, 1889	86,370
The development of annual commerce for every dollar spent on the improvement is about	20

M 12.

IMPROVEMENT OF CAPE FEAR RIVER, AT AND BELOW WILMINGTON, NORTH CAROLINA.

HISTORY OF OPERATIONS.

(1) *Reference to past reports.*—For maps of river, see page 1050, Annual Report for 1887, and 1090 of 1885; for special history of past work, see page 1004, Annual Report for 1886; for last projects, see pages 1132 1134, Annual Report for 1889.

(2) *Original condition.*—The Cape Fear River, emptying into the Atlantic Ocean at Cape Fear, has, from its mouth up to its headwaters in the mountains, a total length of about 426 miles and a drainage area of 9,115 square miles. The two main branches of this river meet at Wilmington, bringing with them an average fresh-water discharge of 14,000 cubic feet per second. Below Wilmington the river is a tidal basin, with about 26 miles length, 350 square miles drainage area, 37 square miles water surface, 3.5 feet average rise of tide (2.5 at Wilmington, 4.5 at the ocean), and an average discharge ebb of 160,000 cubic feet per second, the ocean bar being 2 miles seaward of the river mouth.

When placed under improvement, in 1829, this stream had three bar entrances, with least depths as follows: About 9 feet at the Baldhead Channel, 9 feet at the Rip Channel, and 10 feet at New Inlet Channel, these bars being respectively 9, 6, and 2 miles below the point which was then the head of the river's delta. From the head of this delta, 20 miles up to Wilmington, there were several shoals with a least depth

of 7.5 feet at low water. The commerce in 1827 is unknown, but that of 1870 was about $13,500,000, of which $1,500,000 was foreign export.

(3) *Plan of improvement.*—The original projects of 1827 to 1847 proposed to improve the upper 20 miles by dredging and by jetty contraction of the channel; $203,204.59 were spent during this time in increasing the depth upon the shoals to 9.5 feet at low water, equal to that at the bar entrances. At or about this time the shore at Fort Caswell, opposite Baldhead Point, was protected by stone jetties, under an appropriation for the preservation of fortifications.

The projects of 1852 to 1857 proposed to deepen the water at the main entrance by jetties at Baldhead Point, and by jetty and dike obstructions between Zeke's Island and Smith's Island, near New Inlet, and suggested the possible future necessity of closing New Inlet; $156,296.26 was spent during this time upon these works, never fully completed for want of funds.

The project of 1870 proposed a crib-closure of the space (4,403 feet long) between Smith's and Zeke's Island (finished in 1873) to prevent further widening of New Inlet. The projects of 1870 to 1872 proposed the complete closure of New Inlet (begun in 1875 and finished in 1881), in order to deepen the water at the main (Baldhead) bar entrance. The projects of 1872 to 1883, as continued to date, proposed the extension of the New Inlet Dam 2 miles further down the stream, to prevent the further erosion of Smith's Island at the Swashes. The project of 1875, as continued to date, proposed the occasional use of dredging upon the outer bar to assist the tidal currents in gradually localizing, straightening, deepening, and fixing the bar entrances, to obtain, first, a 12-foot depth at low water, and then a 14-foot depth. The projects of 1874 to 1881 for the 20 miles above New Inlet, as continued to date, proposed dredging and occasional diking wherever necessary across shoals, so as to secure, first, a 12-foot channel 200 feet wide, and afterward a 16-foot channel 270 feet wide at low water over this whole length.

The total final cost of this work under the projects of 1870 to 1885 was, in 1889, estimated to be $2,130,000.

The aggregate amount appropriated for the existing projects of 1872 to 1885 was, up to June 30, 1890, $2,105,000.

In 1889 (see Appendix M 22, Report of Chief of Engineers for 1889) examinations, to comply with requirements of river and harbor act of August 11, 1888, have extended the work of the proposed improvements to obtain a depth of 20 feet at low water from Wilmington to the ocean, at a total increased cost of $1,800,000.

(4) *Results.*—Up to June 30, 1889, a total of $1,903,924.47 had been spent in all upon the proposed improvement of 1870 to 1885, with great success, obtaining a 15 to 15.5 feet least depth of water at the main bar entrance, and completing a channel of 16 feet depth and at least 185 feet width 28 miles farther to Wilmington. This depth, combined with the average rise of tide of 4.5 feet at the bar and 2.5 feet at Wilmington, is such that at that time vessels loaded to 16 feet draught (9.5 feet more than in 1871) could readily go from Wilmington to the ocean in a single tide any day of the year.

The total commerce, exports and imports, foreign and coastwise, had increased from about $13,500,000 of transported goods in 1870 up to about $20,000,000 in 1889, and its foreign exports alone from $1,500,000 in 1871 to about $8,000,000 in 1889, showing that each dollar once spent on this improvement has already been accompanied by the development of about $3.30 of annual foreign commerce, although the last increase of

2 feet in draught in the river channel was too recent to have produced its natural effect on such development.

The navigation of this river below Wilmington is not obstructed by bridges of any sort.

(5) *Work of the past year.*—The special work of the past year is as follows: Expenditures, $189,961.40; value of United States plant, $21,615.

During the year one United States steam-tug, one United States steam-suction dredge, and other United States plant were in use.

From July 1, 1889, to May 21, 1890, there were employed from two to five contract dredges on the improvement.

Owing to its variable nature and to the difficulty of properly specifying it beforehand and measuring it afterwards, all work except dredging was, for advantage and economy, allowably done by hired labor and the purchase of materials in open market. The dredging was done partly under contract dated January 14, 1889, with the Atlas Dredging Company, of Wilmington, Del., to be finished by February 11, 1890; the contract price being 12½ cents per cubic yard for the first $123,000 and 12 cents per cubic yard for the additional $62,000 worth; partly under agreements of April, 1890, with the American Dredging Company, of Philadelphia, Pa.; the Alabama Dredging and Jettying Company, of Mobile, Ala., and Ross & Sandford, Savannah, Ga. (the price under all these agreements being 12 cents per cubic yard), and partly by hired labor by the United States steam-suction dredge *Woodbury*.

All work done under the contract with the Atlas Dredging Company was performed in a very thorough and highly satisfactory manner. This contract was completed on April 30, 1890. The Atlas Dredging Company employed the following-named dredges and removed from the various shoals of the river 1,237,936⅔ cubic yards mud and sand, 3 logs and 134 stumps, viz:

Name of dredge.	Mud and sand.	Logs.	Stumps.	
			$10.	$30.
	Cubic yards.			
Vim	324,553	3	5	115
Pugh	313,388⅔	.....	2	4
Admiral	299,795	.....	.....	.....
Alabama	129,203	.....	.....	.....
Savannah	170,997	.....	.....	8
Total	1,237,936⅔	3	7	127

After the completion of this contract there still remained available the sum of about $12,000 for work on this improvement.

As it was very desirable that the new cut at Snow's Marsh Channel should be carried to full depth over as much of its width as possible, authority was asked and obtained for arranging in open market for about $10,000 of additional dredging, this method being deemed most advantageous and economical to the United States.

Under this authority the above-mentioned agreements with three different dredge owners were entered into at a uniform price of 12 cents per cubic yard.

This dredging was completed very satisfactorily May 20, 1890.

The American Dredging Company employing the dredge *Admiral*, removed from the new cut at Snow's Marsh 26,105 cubic yards of mud

and sand; the Alabama Dredging and Jettying Company employing the dredge *Pugh*, removed from the same locality 25,208⅓ cubic yards mud and sand, and Ross and Sanford employing the dredge *Savannah*, removed from the same locality 24,341 cubic yards of mud and sand.

During the fiscal year the *Woodbury*, operated by hired labor and the purchase of materials in open market, removed 85,922 cubic yards of mud and sand at a total cost of $11,087.73, or 12.9 cents per cubic yard. Between June 30, 1889, and June 30, 1890, this dredge removed from the ocean bar (29 miles below Wilmington) 52,307 cubic yards of sand, leaving a straight channel of at least 200 feet width and at least 16 feet depth at mean low water. All large boats now use this channel. Between the same dates, but during weather unsuited for work on the bar, the *Woodbury* removed from the old Snow's Marsh Channel (20 miles below Wilmington) 32,702 cubic yards of sand and mud; from Reaves's Point Shoal 913 cubic yards of sand and mud.

Between November 2 and November 29, 1889, the *Woodbury* was laid up at Wilmington undergoing repairs to her shaft and propeller, and between May 15 and June 30, 1890, she was also laid up while a new suction-pump was being put in to replace the old one, worn out, and while repairs were being made to her main crank.

The total work of all the above-mentioned dredges during the year is as follows:

From the New Cut at Snow's Marsh Channel (20 miles below Wilmington) there were removed 807,551 cubic yards of mud and sand, leaving the cut everywhere 233 feet wide and 16 feet deep at low water.

From the Old Snow's Marsh Channel (20 miles below Wilmington) there were removed 81,716 cubic yards of mud and sand, leaving the cut everywhere at least 90 feet wide and 16 feet deep at low water.

From Reaves's Point Shoal (19 miles below Wilmington) there were removed 47,255 cubic yards of mud and sand, leaving the cut everywhere 270 feet wide and 16 feet deep at low water.

From Midnight Shoal (16 miles below Wilmington) there were removed 100,287 cubic yards of sand and mud, leaving the cut everywhere 270 feet wide and 16 feet deep at low water.

From Lilliput Shoal (11 miles below Wilmington) there were removed 172,327 cubic yards of mud and sand, leaving the cut everywhere 270 feet wide and 16 feet deep at low water.

From Logs and Big Island Shoal (7 miles below Wilmington) there were removed 138,070 cubic yards of mud and sand, 127 cypress stumps, 7 pine stumps, and 4 logs, leaving the cut everywhere 270 feet wide and 16 feet deep at low water.

Inspections of property and work were made during the year, showing very satisfactory results everywhere.

The work of this improvement has been vigorously and very thoroughly carried on under the immediate supervision of Assistant Engineer Henry Bacon, whose report is herewith appended.

The work of the past year has greatly benefited the navigation of the river. In the upper river the channels are everywhere of full width and depth, and vessels drawing 18 feet have safely ascended and descended the river.

The single straight channel on the ocean bar has been maintained, and its depth increased by natural scour and by the work of the United States suction-dredge *Woodbury*.

The new channel at Snow's Marsh is now being used by all vessels, and there is every indication that it will prove to be very successful and permanent.

The foreign commerce is steadily increasing. Otherwise the situation remains about the same as at the beginning of the fiscal year.

The latest reliable commercial statistics, those for the year ending December 31, 1889, are herewith appended, showing a commerce of about $20,246,664 per year (about 342,212 tons).

(6) *Recommendations for future work.*—It is recommended that the above improvements be carried on by widening and deepening the existing river channels to their full dimensions of 270 feet width and 16 feet least depth at low water, and by straightening, deepening, and fixing the bar entrance, at a total expense of $25,000, in addition to the funds available June 30, 1890, this whole amount to be appropriated in one sum during the next fiscal year; and to increase present depths to 20 feet at low water at a further total expense of $1,800,000, to be appropriated in amounts of $300,000 per year. Smaller yearly appropriations, involving the alternate disorganization and reorganization of working parties, damage to unfinished work, deterioration of plant, and extra superintendence may increase the cost of the work by from $6,000 to $20,000 per appropriation.

After this improvement is finished its proper maintenance may cost from $5,000 to $25,000 per year for a few years, but the improvement should be fairly permanent.

This river is in the collection district of Wilmington, N. C.

Money statement.

July 1, 1889, amount available		$201,075.53
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$187,599.49	
July 1, 1890, outstanding liabilities	2,361.91	
		189,961.40
July 1, 1890, balance available		11,114.13
Amount appropriated by act of September 19, 1890		170,000.00
Amount available for fiscal year ending June 30, 1891		181,114.13
Amount (estimated) required for completion of existing project		1,655,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		300,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

REPORT OF MR. HENRY BACON, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Wilmington, N. C., July 1, 1890.

CAPTAIN: I have the honor to submit the following report of operations for the improvement of Cape Fear River, North Carolina, below Wilmington, for the year ending June 30, 1890.

It has been a year of continuous work under projects previously discussed and determined. Some progress had previously been made in the work, but not at a rate which promised completion, as far as the appropriation would allow, within the year. The work has consisted mostly of dredging in the river channels below Wilmington, and the operations of the suction-dredge *Woodbury* on the bar of the Baldhead Channel and at the Old Snow's Marsh Channel.

The dredging in the river has been in continuation and near completion of the project of 1881, cutting channels wherever required to give a depth of 16 feet at mean low water and a width of 270 feet from Wilmington to the deep water of Southport Harbor. The work was under contract with the Atlas Dredging Company, and was in progress at the end of the last year. The channels through the shoals known as the "Wilmington," "Kidder's" (or "Alligator Creek") and "Brunswick River"

PROGRESS MAP FOR 1890.

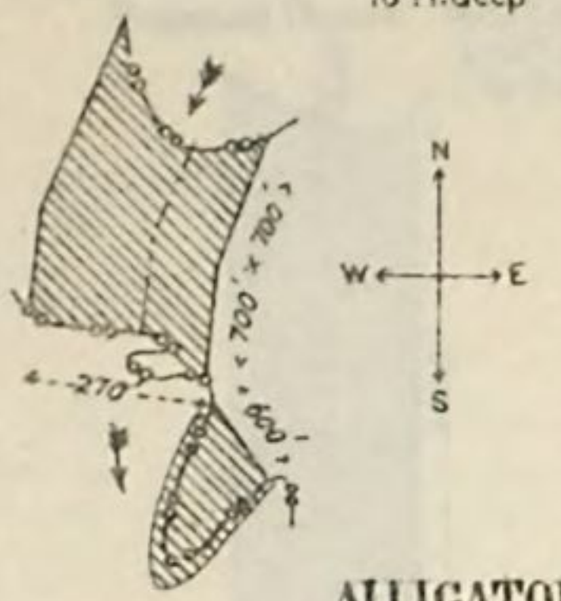
CAPE FEAR RIVER FROM WILMINGTON, N.C.

FROM 1. JULY 1889 TO 30. JUNE 1890.

SHEET Nº 1

WILMINGTON SHOAL

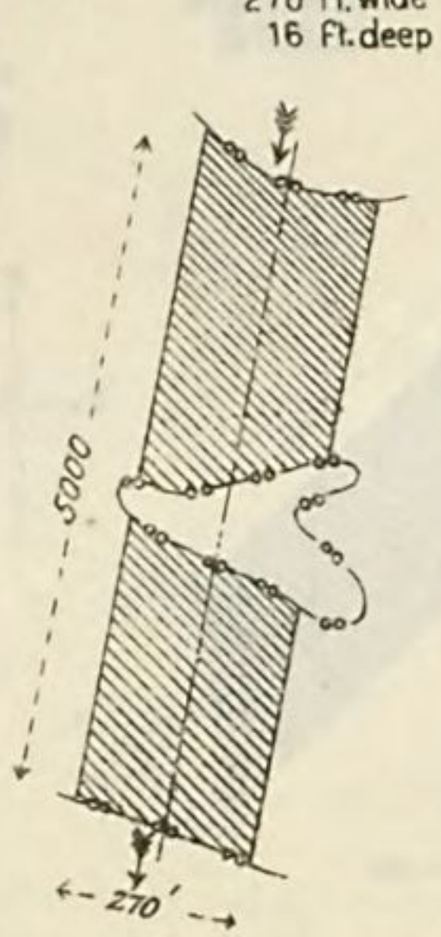
Proposed Channel 2000 ft. long
270 ft. wide
16 ft. deep



BRUNSWICK RIVER SHOAL

3 MILES BELOW WILMINGTON

Proposed Channel: 5000 ft. long
270 ft. wide
16 ft. deep

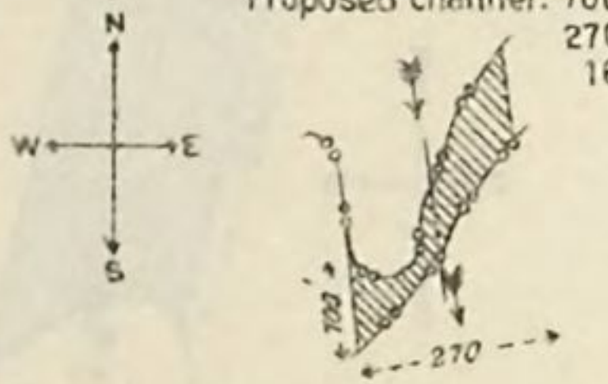


ALLIGATOR CREEK SHOAL

(OPPOSITE KIDDER'S MILL)

1 MILE BELOW WILMINGTON

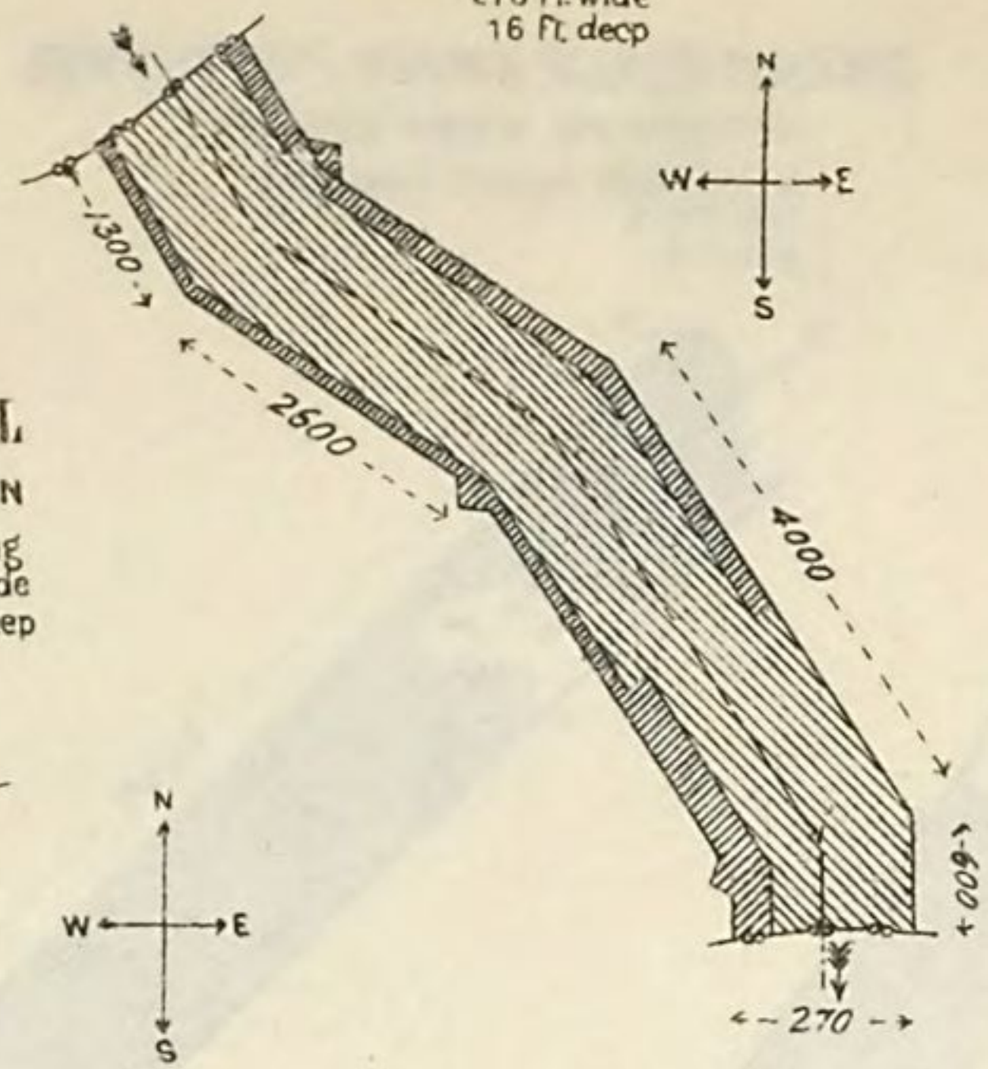
Proposed Channel: 700 ft. long
270 ft. wide
16 ft. deep



LOGS & BIG ISLAND SHOAL

7 MILES BELOW WILMINGTON

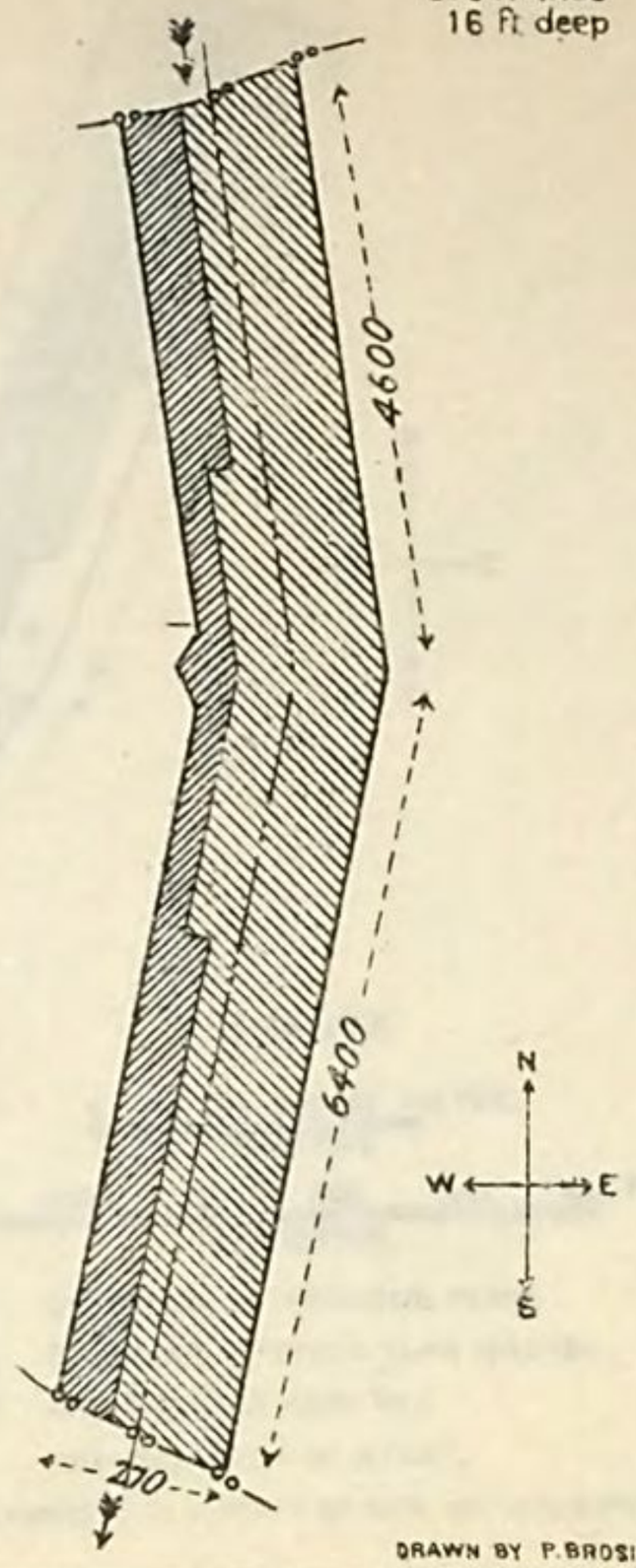
Proposed Channel: 8500 ft. long
270 ft. wide
16 ft. deep



LILLIPUT SHOAL

11 MILES BELOW WILMINGTON

Proposed Channel: 11000 ft. long
270 ft. wide
16 ft. deep



SCALES

0 100 200 300 400 500 FEET.
WIDTHS

0 1000 2000 3000 4000 5000 FEET
LENGTHS

- DREDGING OF PREVIOUS YEARS
- DREDGING OF FISCAL YEAR 1889-90.
- UNCOMPLETED CHANNEL
- NATURAL DEPTH OF 16 FT.

ALL DREDGING IS TO BE CARRIED TO A DEPTH OF 16 FT. AT LOW WATER

Wilmington N.C. July 1890.

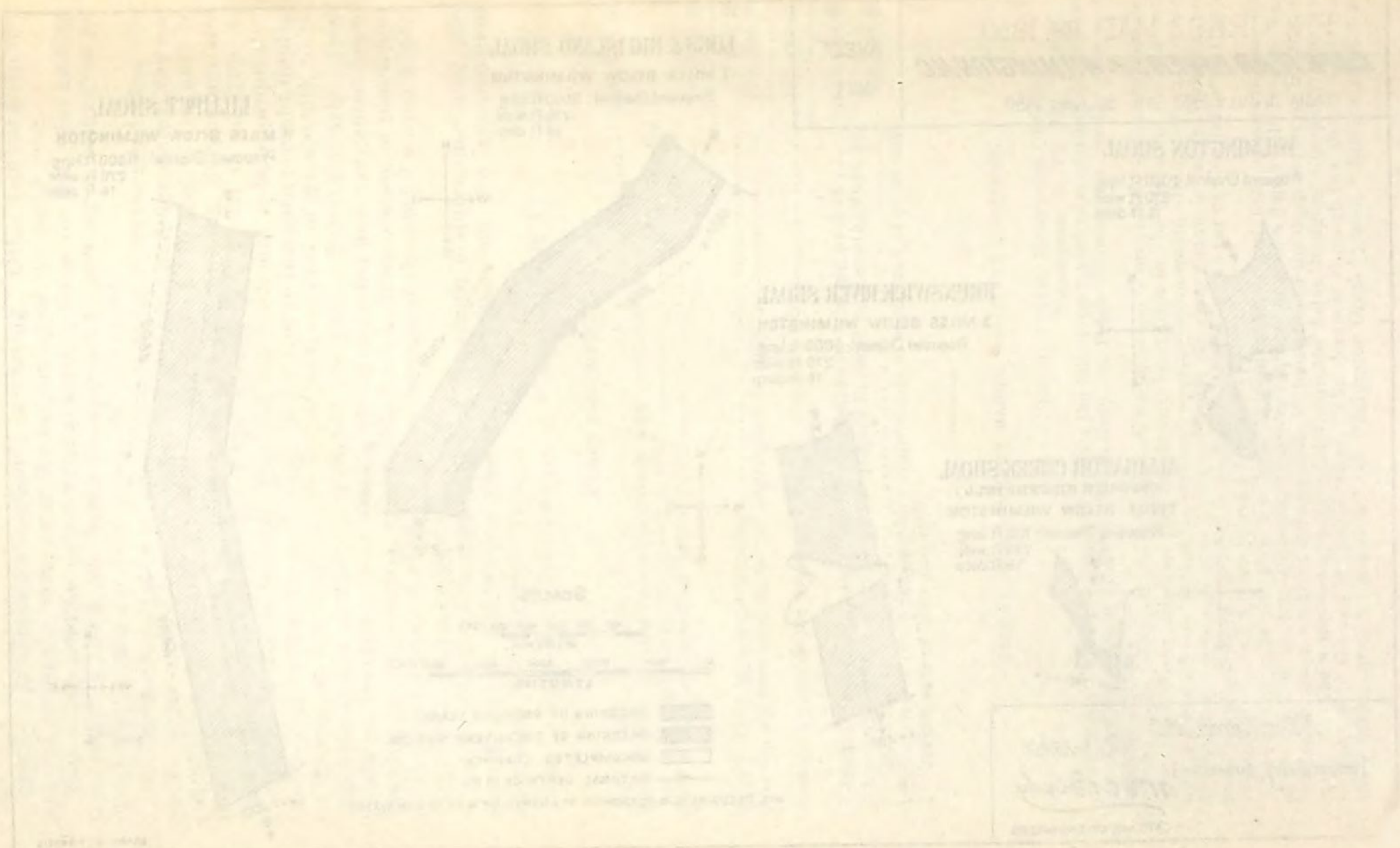
Respectfully submitted

Wm. H. C. Bixby

CAPTAIN OF ENGINEERS

DRAWN BY P. BROSIG

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PROGRESS MAP FOR 1890.

CAPE FEAR RIVER BELOW WILMINGTON N.C.

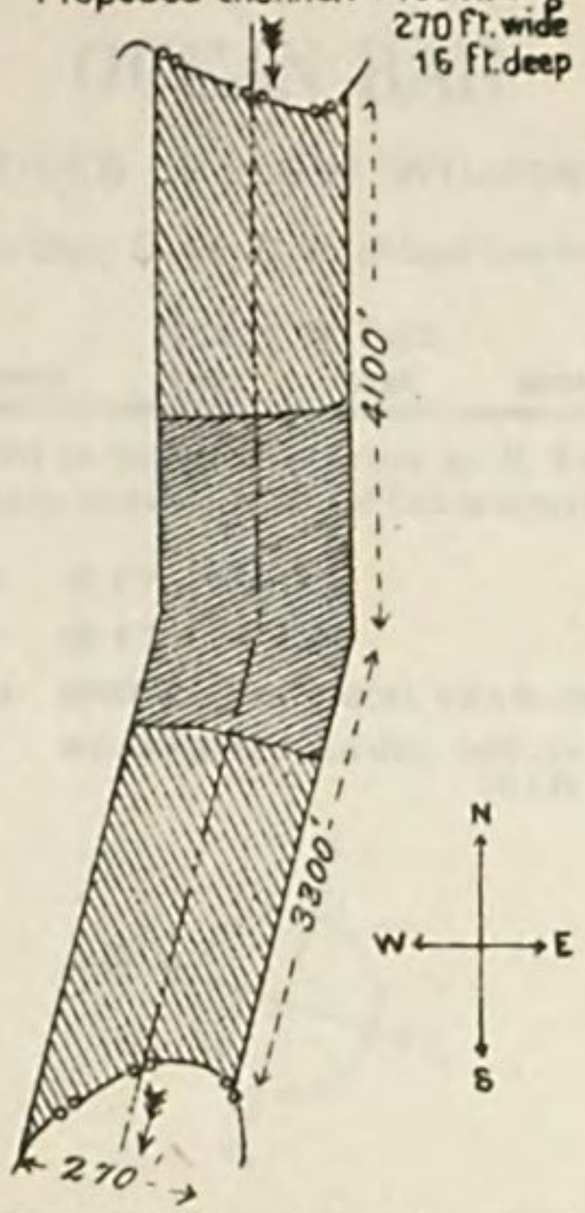
FROM 1. JULY 1889 TO 30. JUNE 1890.

SHEET Nº2

MIDNIGHT SHOAL

16 MILES BELOW WILMINGTON

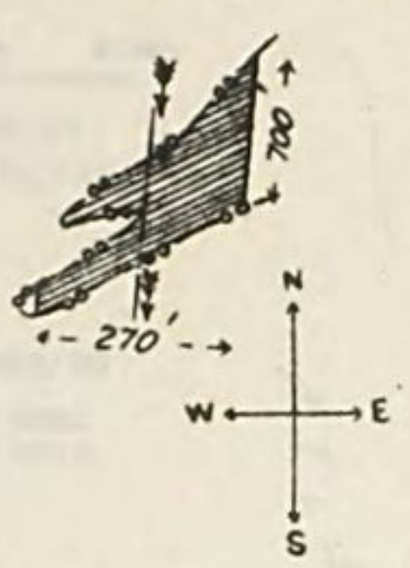
Proposed Channel: 7400 ft. long
270 ft. wide
16 ft. deep



REAVES POINT SHOAL

19 MILES BELOW WILMINGTON

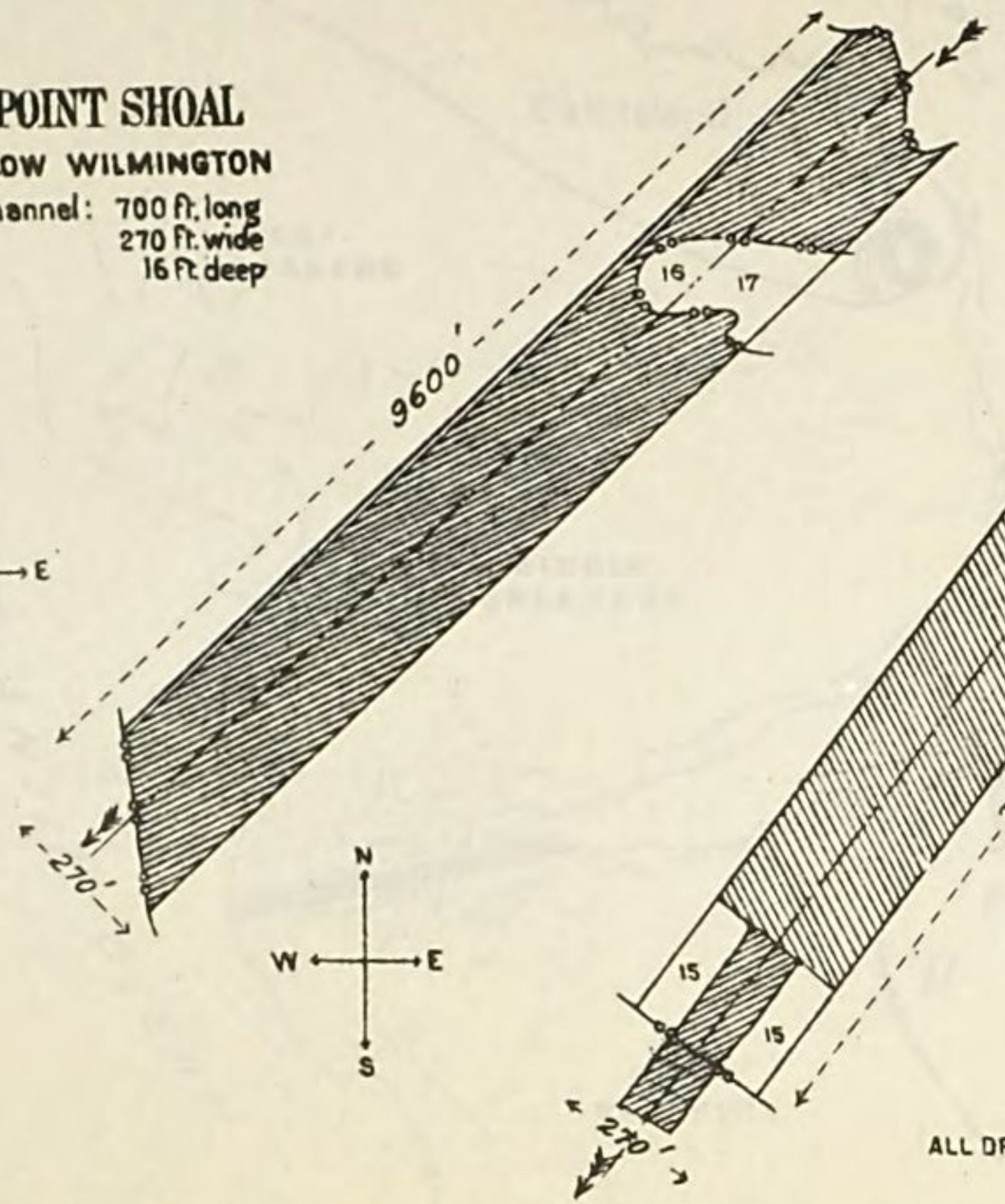
Proposed Channel: 700 ft. long
270 ft. wide
16 ft. deep



NEW CUT OPPOSITE SNOWS MARSH CHANNEL

20 MILES BELOW WILMINGTON

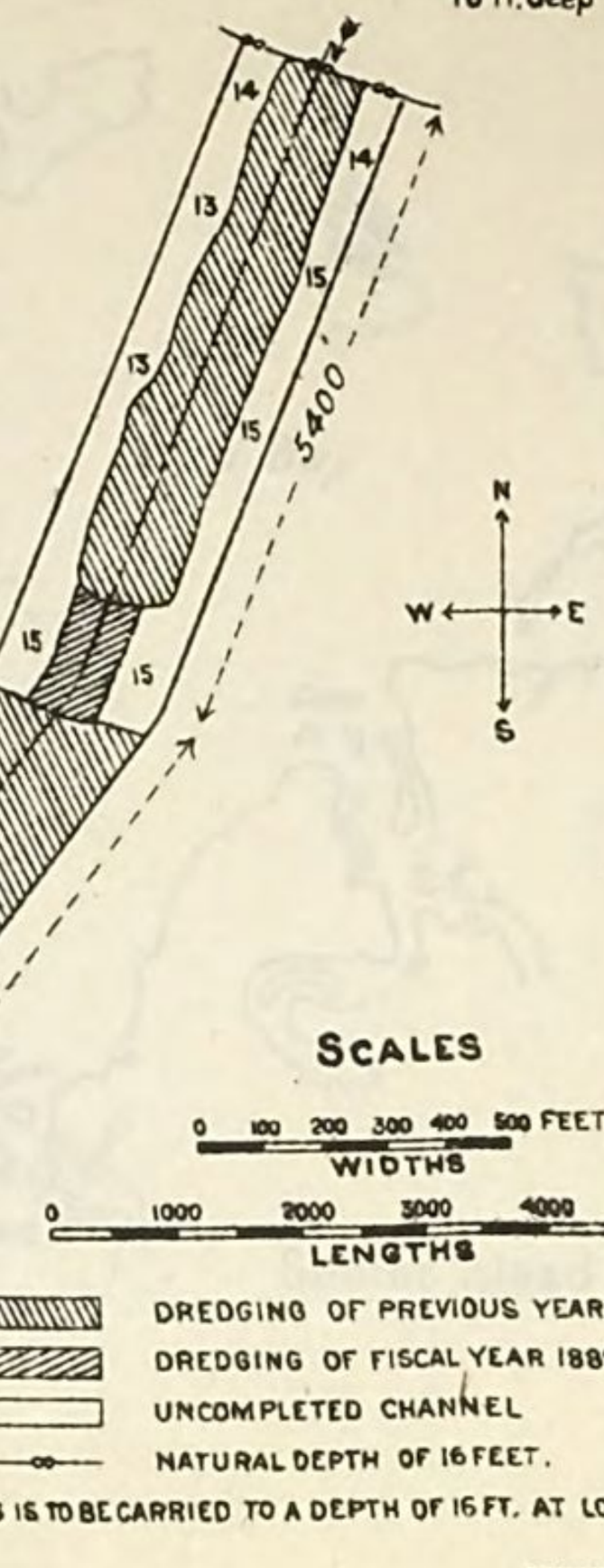
Proposed Channel: 9600 ft. long.
270 ft. wide.
16 ft. deep.



OLD CUT, SNOWS MARSH CHANNEL

20 MILES BELOW WILMINGTON

Existing Channel: 13000 ft. long
Originally dredged to 270 ft. wide
16 ft. deep



SCALES

0 100 200 300 400 500 FEET
WIDTHS

0 1000 2000 3000 4000 5000 FEET
LENGTHS

- DREDGING OF PREVIOUS YEARS
- DREDGING OF FISCAL YEAR 1889-90.
- UNCOMPLETED CHANNEL
- NATURAL DEPTH OF 16 FEET.

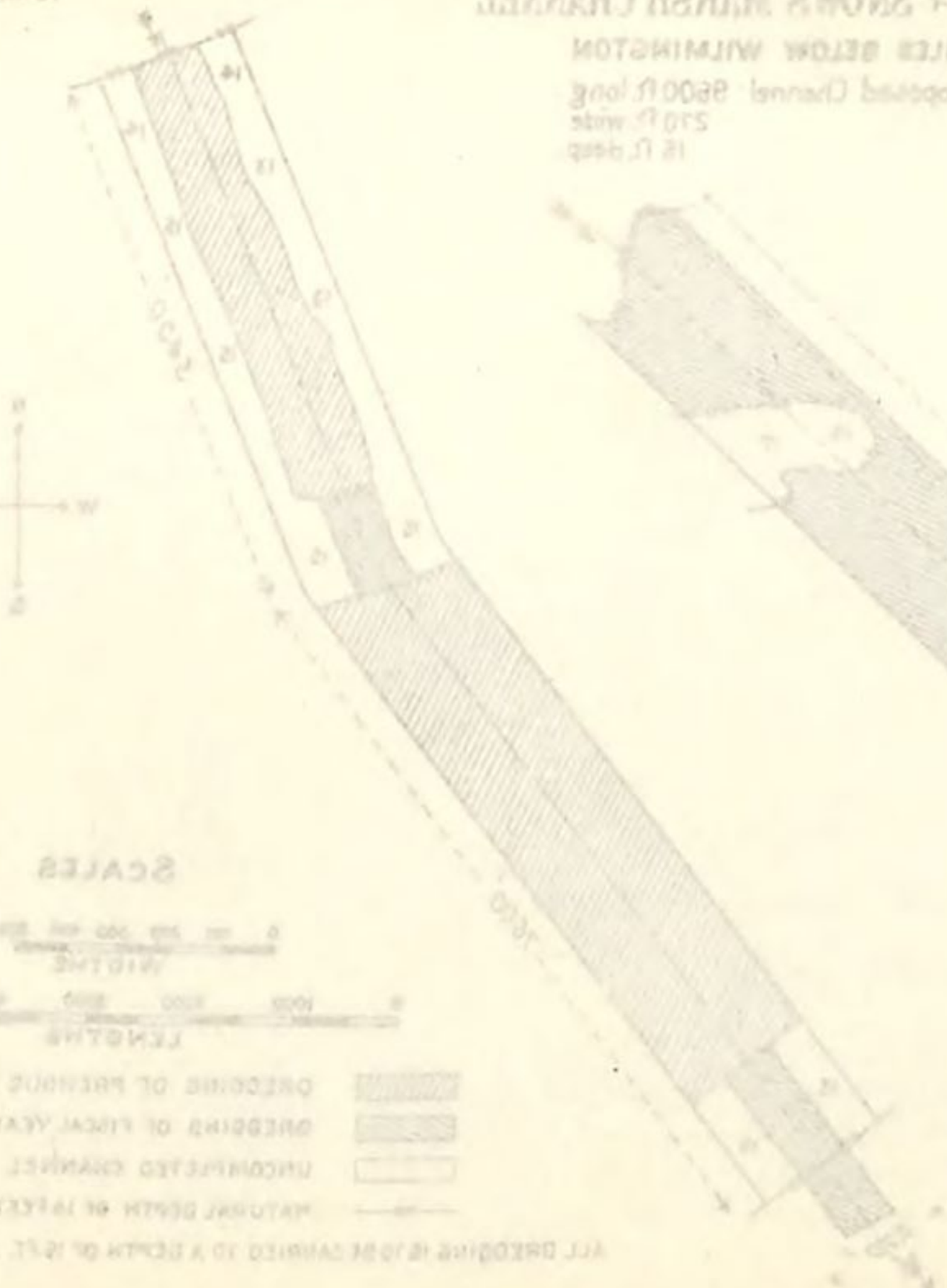
ALL DREDGING IS TO BE CARRIED TO A DEPTH OF 16 FT. AT LOW WATER.

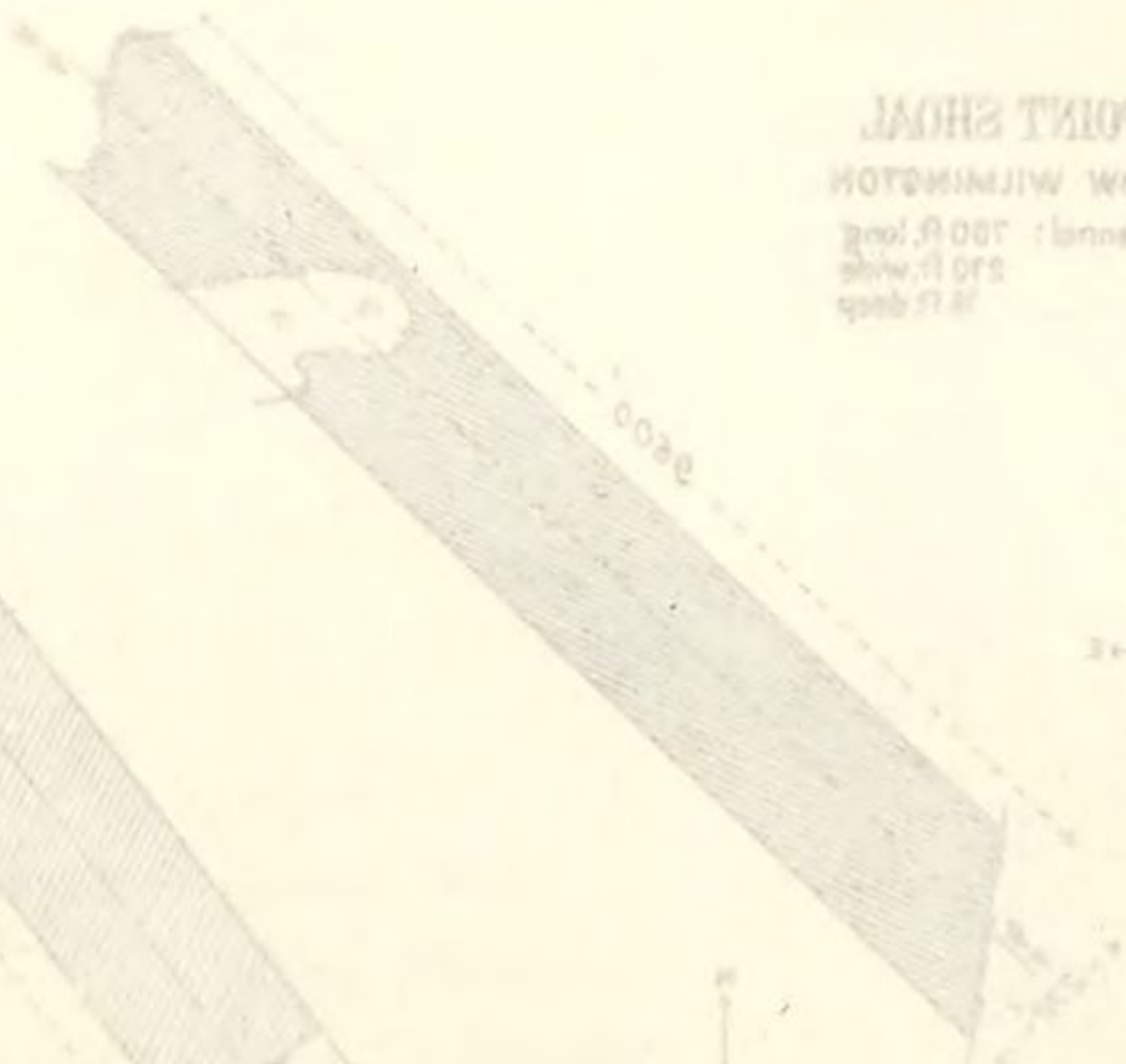
DRAWN BY P. BROSIG.

Wilmington N.C.
July 1890.

Respectfully submitted
W. H. C. Bixby
CAPTAIN OF ENGINEERS

SHEET
NO 2





PROGRESS MAP FOR 1890
CAPE FEAR RIVER BELOW WILMINGTON, N.C.

FROM 1. JULY 1889 TO 30. JUNE 1890.

SHEET
№3.

OCEAN BAR
29 MILES BELOW WILMINGTON

Based on Coast Survey Chart of Cape Fear River - 1888.

SCALE OF FEET
0 2000 4000 6000 8000 10000

Corrected to date from surveys by H. Bacon,
made under direction of Capt. W.H. Bixby, U.S. Engrs.

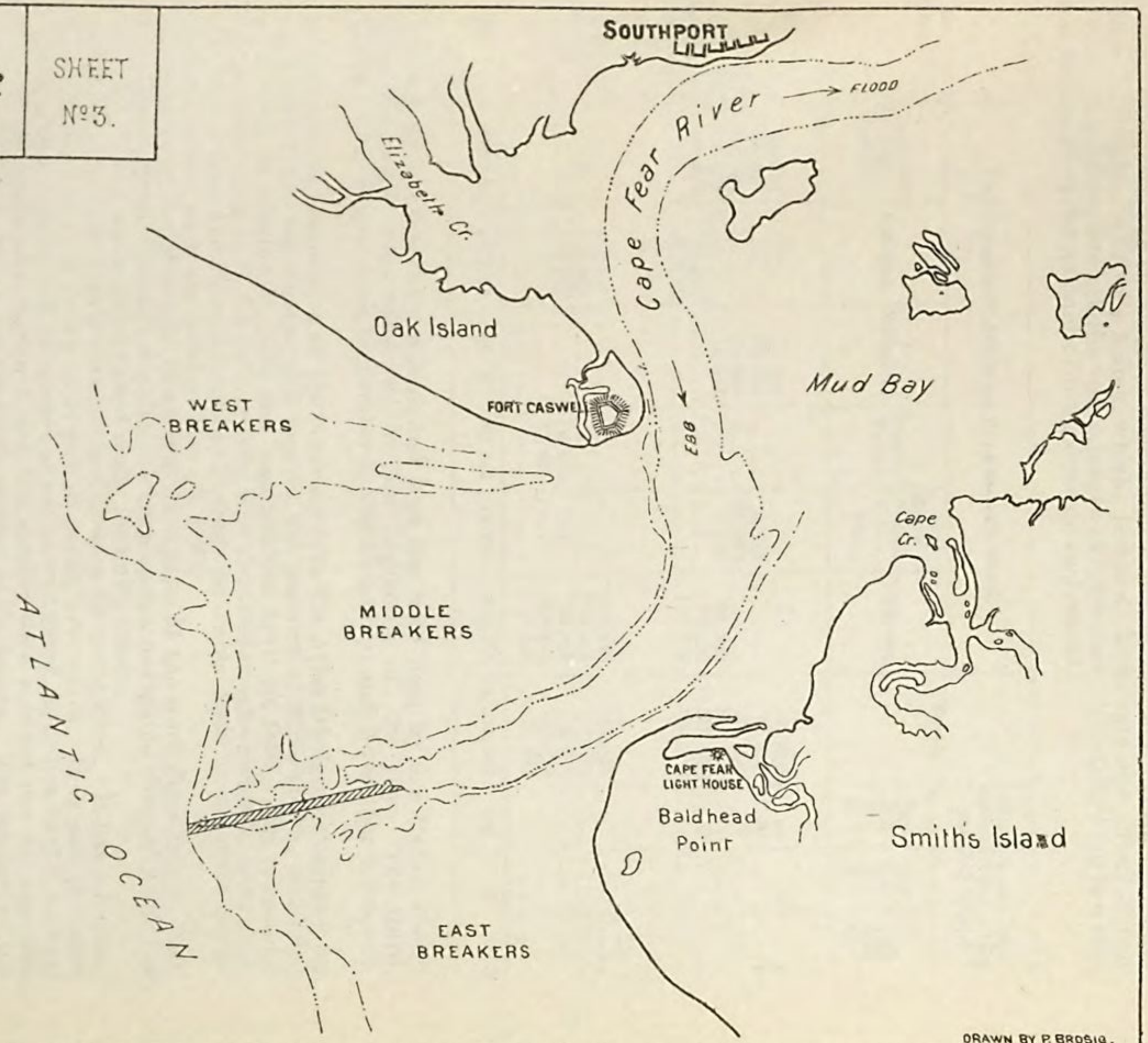
— · — 12 FT. CONTOUR
— ····— 18 FT. CONTOUR
▨ DREDGING OF FISCAL YEAR 1889/90.
NAVIGABLE CHANNEL 200+ Ft. WIDE
16+ Ft. DEEP

N
W E
S

Wilmington, N.C. *July 1890*

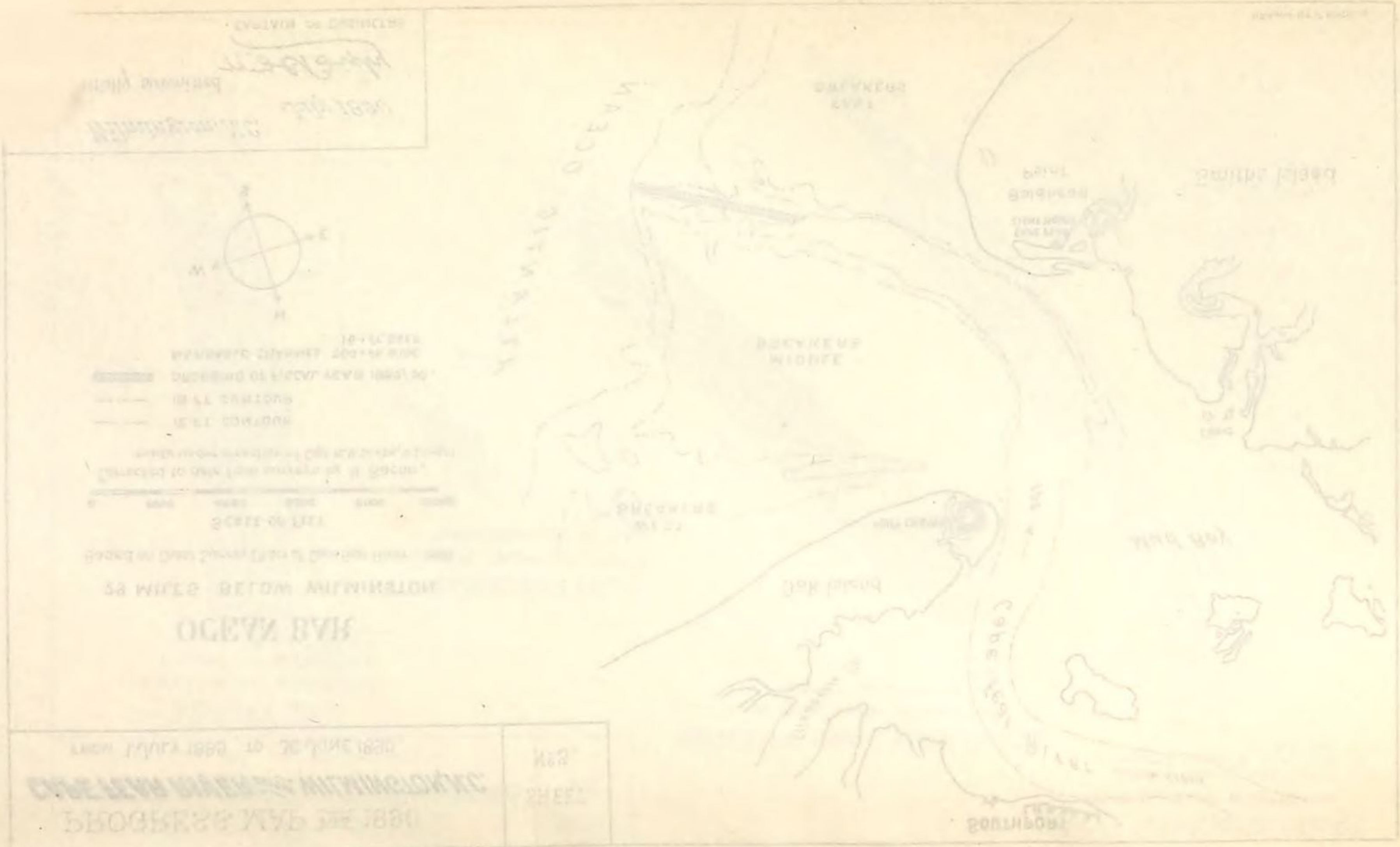
Respectfully submitted *W. H. C. Bixby*

CAPTAIN OF ENGINEERS



DRAWN BY P. BROSIG.

Eng 90



were completed to the full width and depth at the beginning of the year. The channels at all the remaining shoals have been finished during the year, excepting that of the New Cut opposite Snow's Marsh, which, however, lacks only one cut of 37 feet width of completion through the whole length of 9,600 feet. The following is a tabulated statement of the amount of work done on each shoal:

Month.	Cubic yards of dredging done at each shoal.						Total.	Stumps and logs removed from Log and Big Island.		
	Log and Big Island.	Lilliput.	Midnight.	Reaves' Point.	Snow's Marsh Channel.	New cut.		Stumps at $30.	Stumps at $10.	Logs at $20.
1889.										
July	45,926	.....	11,703	.....	.....	.....	57,629	12	7	1
August	25,549	.....	48,592	.....	3,496	.....	77,637	66	.....	1
September	21,158	.....	25,948	.....	38,985	.....	86,091	33	.....	.....
October	26,312	.....	14,044	.....	6,533	94,256	141,145	7	.....	1
November	19,125	32,995	.....	.....	.....	79,180	131,300	9	.....	.....
December	.....	49,210	.....	.....	.....	107,718	156,928	....	.....	.....
1890.										
January	.....	52,462	.....	.....	.....	128,475	180,937	.....	.....	.....
February	.....	34,988	.....	.....	.....	100,994	135,892	.....	.....	.....
March	.....	2,672	.....	28,405	.....	109,859	140,936	.....	.....	.....
April	.....	.....	.....	17,937	.....	114,653	132,590	.....	.....	.....
May	.....	.....	.....	.....	.....	72,506	72,506	.....	.....	.....
Total	138,070	172,327	100,287	46,342	49,014	807,551	1,313,591	127	7	3

The dredging and removing stumps and logs has been done by five "clam-shell" dredges. Two only were employed at the beginning of the year. The third, fourth, and fifth began work September 4, September 11, and November 6, respectively.

The time for the completion of the contract with the Atlas Dredging Company for dredging and removing stumps and logs to the amount of $185,000 was extended from February 11 to June 30, 1890, and was finished April 30, 1890. The remaining dredging, amounting to 75,654 cubic yards, was done under agreements in open market by three parties and three dredges at 12 cents per cubic yard (a continuation of the contract price), and was finished May 20, 1890.

The dredging at the Midnight Shoal was for repairs of the work done late in 1883. That at Snow's Marsh Channel was done to keep open a navigable channel while the New Cut was being made and finished ready for navigation.

The New Cut is now nearly finished and is open for navigation. It has a bottom width of 233 feet with a depth of 16 feet at mean low water. It is not probable that much if any repairs will be needed at the new channel, as it lies in the natural direction of the main tidal currents, and has already been scoured out to a greater depth than dredged over a considerable portion of its length. The wisdom of the change from the Old Snow's Marsh Cut seems already demonstrated.

Some deterioration should be expected in channels dredged in such a wide tidal river or estuary, but much less has occurred than might reasonably have been looked for.

The United States suction-dredge *Woodbury* has been employed on the Baldhead Channel and Bar when wind and weather permitted and at other times in the river, mostly at Snow's Marsh Channel. She has been laid up for repairs more than two months of the year, first on account of a broken shaft, and lastly a broken main crank. The following is a tabular statement of the amount of work done, and the cost of the same per cubic yard and cost in gross, allowing $100 per month for deterioration of plant, and paying for a new section of main shaft and a new set of suction-pipes. The account, made for eleven months, to June 1, 1890, amounts to $10,486.87 and 85,922 cubic yards, making the cost 12.2 cents per cubic yard.

The cost per yard for the whole year exceeds the above on account of the expenses of the new crank, new main pump, and other expenses in June, while not in operation.

Month.	Cubic yards of dredging done and the number of days dredged.						Total.		Cost.	
	Days.	Bar.	Days.	Snow's Marsh.	Days.	Reaves' Point.	Days.	Yards.	Whole cost.	Per yard.
1889.										
July	5	2,319	17	6,534	.....	.....	22	8,853	$977.32	$0.1104
August	16	7,695	4	1,729	.....	.....	20	9,424	1,076.71	.1104
September	17	8,283	4	1,013	1	355	21	9,651	924.73	.0958
October	18	8,675	2	797	2	558	20	10,030	942.81	.0094
November	1	417	.....	.....	.....	.....	1	417	810.05	1.9425
December	17	6,812	5	1,549	.....	.....	22	8,361	945.56	.1119
1890.										
January	10	4,689	9	3,881	.....	.....	19	8,570	968.42	.1130
February	5	2,533	12	5,016	.....	.....	17	7,549	962.83	.1175
March	5	2,271	14	6,727	.....	.....	19	8,998	888.60	.0987
April	12	6,265	8	3,276	.....	.....	20	9,541	1,193.62	.1251
May	4	2,348	5	2,180	.....	.....	9	4,528	796.32	.1752
June	.....	.....	.....	.....	.....	.....	.....	.....	600.86	.....
Total	110	52,307	80	32,702	3	913	190	85,922	11,087.73	*.1290

* Average.

The total cost for the twelve months, up to July 1, was therefore $11,087.73, equal 12.9 cents per cubic yard.

The ordinary cost is about 11 cents per yard. Taking nine months of the year, leaving out November, May, and June, when heavy and unusual repairs were made, the cost is 10.96 cents per cubic yard.

The work at the Snow's Marsh Channel was done to assist in keeping it open for navigation while the new channel was being cut.

The results of the dredging at the bar assisting the natural scouring are gratifying. Seventeen feet depth at mean low water can now be carried from deep water inside across the bar.

At the outer crest, or bar, the width from 18 feet depth inside to 18 feet depth outside is but 200 feet, and between the 20 foot curves the distance is but 400 feet. There are some inner shoals about 3,000 feet inside of the bar where the available depth does not exceed 17 feet. These yield more readily to the work of the *Woodbury* than the shoal at the outer crest.

There can be but little doubt that the continuous operation of the *Woodbury* during the coming year will secure and maintain a good navigable channel across the shoals and the bar of at least 18 feet depth at mean low water.

The results of the work of the year may be summarized as follows:

Across all the shoals in the river below Wilmington channels are finished 270 feet wide (excepting at the New Cut, where the width is only 233 feet) with 16 feet depth at mean low water, and an extra width of 37 feet at the three projecting angles of the Logs and Big Island Channel; and across the shoals and bar at the entrance of the river a navigable channel has been opened to 17 feet depth at mean low water; so that vessels can be taken from Wilmington to Southport Harbor drawing 18 feet, and from thence to sea at ordinary high tide with 19½ feet draught, and at spring tides with 20 to 21 feet. Such results are encouraging for future operations.

The New Inlet Dam and the long new dam extending from the southerly end of it to the large marsh remain in substantially the same finished condition as at the last report. Their combined length is 3¼ miles. The results show the accomplishment of the object of the construction of the New Inlet Dam, and a close approximation to, if not an entire fulfillment of the object of the new dam. The design of the New Inlet Dam was to shut off the New Inlet and turn all the tidal currents through the main entrance, and thus deepen the water at the bar. The new dam was designed as a defense against the swashes from the ocean across the narrow beach of Smith's Island, which were in danger of ultimate approach to the main channel of the river, and through which strong tidal currents passed to and from the river, and might, in the course of time, form an inlet from the ocean as formidable as that shut off by the first dam. This danger has been wholly obviated by the new dam. It

was expected (though not confidently predicted at the beginning) that the construction of the new dam would cause the natural closure of the swashes. The results thus far point in that direction. If they are thus closed, the long narrow beach must become wider and stronger than ever before, and what will remain of Buzzard's Bay will form a part of the tidal reservoir of the entrance. The swashes spoken of are three in number, one small one near the head of Smith's Island, the main swash about 2 miles farther southward, called on the latest Coast Survey map "Goldleaf Inlet," and the third about a mile southward of the last, called on the Coast Survey chart "Corncake Inlet."

During the past three years there has been a continual diminution in width of the inlets or swashes. The depths have also decreased on the bars, both on the sea-side and in Buzzard's Bay inside. The following is a table of the widths of the swashes at high water in June, 1887, 1888, 1889, and 1890. The widths at low water have diminished in about the same proportion:

Year.	North swash.	Main swash, Goldleaf Inlet.	South swash, Corncake Inlet.	Total width at high water.
	Feet.	*Feet.*	*Feet.*	*Feet.*
1887	300	2,500	1,600	4,400
1888	280	2,700	350	3,330
1889	270	2,390	150	2,810
1890	230	1,790	100	2,120

No material changes have occurred in the shore-lines of Zeke's Island, Federal Point, and the long beach which extends from the Federal Point beach about 1½ miles easterly of the point over the site of the Carolina Shoals southwesterly about 2 miles, nearly to the head of Smith's Island. Here is the only inlet from the sea to the New Inlet basin. It is only 450 feet wide at high water and about 170 feet at low water, and is growing more and more shoal, so that the basin does not entirely fill with the tides. The existence of this basin may perpetuate the inlet.

There has been considerable accretion at the shore-lines of Baldhead Point. It has increased from year to year southerly and southeasterly from the point, while there has been a continual abrasion at the point until the year 1889. Since then there has been considerable accretion at the point as well as further south and southeasterly. A tracing will be submitted with this showing these changes, and also the hydrography of the Baldhead Channel. No great changes have occurred in the shore-line of Oak Island. There has been some abrasion at the point and along the shore opposite Fort Caswell, and some accretion further westward towards Oak Island Light-House.

Several hydrographical surveys have been made of the Baldhead Channel and vicinity and of the dredged channels.

Surveys have been made of the beaches of Baldhead Point and vicinity, Zeke's Island, and Smith's Island, Federal Point, and the Caroline Shoals.

The total amount of appropriations by Congress (beginning with $100,000 June 11, 1870, and ending with August 11, 1888, $245,000) is $2,105,000.

The following is the estimate of the amount required to complete the project of obtaining 20 feet depth at mean low water from Wilmington to the ocean and 270 feet width in the river and 500 feet at the bar.

The estimate of last year is repeated, adding 125,000 cubic yards of dredging to complete the project of 1881 for 16 feet depth.

4,850,000 cubic yards dredging, at 15 cents	$727,500
180,000 tons of stone in jetty, at $2.50	450,000
Two new suction dredges	90,000
Operating the same twenty-four months, at $1,750 per month	84,000
Operating the *Woodbury* twenty-four months, at $1,000 per month	24,000
Add 10 per cent. for office expenses and superintendence	137,550
Add 10 per cent. for contingencies	137,550
Total	1,650,600

I will request the collector of the port to send you a statement of the amount of revenue collections for the fiscal year.

I am indebted to Col. John L. Cantwell, secretary of the Produce Exchange and Chamber of Commerce of Wilmington for his valuable assistance in obtaining the commercial statistics for the year 1889, which have been heretofore forwarded.

From these statistics it appears that there has been a slight diminution in the amount of commerce for the year, which was caused solely by the partial failure of the cotton crop. Aside from cotton there has been a general increase.

The work is in the collection district of Wilmington, N. C. The nearest lighthouses are at Baldhead and Oak Island, at the mouth of the river.

Very respectfully, your obedient servant,

HENRY BACON,
Assistant Engineer.

Capt. W. H. BIXBY,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

When the work of this improvement was begun, in 1829, the river navigation was restricted to vessels of 7½ feet draught. The river commerce at that date is unknown. At present the river is used by vessels of 17 feet draught; its commerce is about $20,000,000 per year, and is steadily increasing. The commerce for the past year shows a slight falling off, but that is due to the partial failure of the cotton crop.

The rates of freight have greatly decreased since the improvement was begun. The rates of insurance have decreased to such an extent that while formerly there was a discrimination against Wilmington in favor of other southern points, now Wilmington is put on an equality with Charleston and Savannah.

The foreign commerce has increased from $1,500,000 in 1871, to over $8,000,000 in 1889.

The development of this port directly tends to the development of North Carolina and of such of the Western States as can reach Europe most quickly by the existing and projected North Carolina railroads, the Cape Fear River, and the Ocean.

Exports, foreign and domestic, for the years ending December 31, 1888 *and* 1889.

Articles.	Quantity.		Rate.		Value, 1888.	Value, 1889.
	1888.	1889.	1888.	1889		
Cotton.....bales..	162, 993	132, 994	$50. 00	$51. 62½	$8, 149, 650	$6, 865, 815
Spirits of turpentine.....barrels..	63, 473	61, 626	17. 50	21. 56	1, 110, 778	1, 328, 657
Crude turpentine .....do....	21, 572	18, 171	1. 50	1. 49	32, 358	27, 075
Rosin .....do....	246, 566	351, 827	1. 00	. 94	246, 566	330, 717
Tar .....do....	63, 163	68, 865	1. 30	1. 56	82, 112	107, 429
Pitch .....do....	8, 489	5, 269	1. 60	1. 60	13, 582	8 430
Peanuts .....bushels..	40, 397	80, 302	. 75	1. 00	30, 298	80, 302
Lumber.....feet..	36, 679, 509	40, 289, 205	. 01½	. 01½	550, 193	604, 338
Shingles .....No..	6, 663, 980	7, 316, 912	. 00 11/20	. 00 8/20	36, 652	43, 901
Miscellaneous (estimated).....	.....	.....	.....	.....	3, 500, 000	3, 500, 000
Total	.....	.....	.....	.....	13, 752, 189	12, 896, 664

Imports, foreign and domestic.

Years.	Estimated quantity.	Estimated value.
1888 .....tons..	98, 000	$7, 350, 000
1889 .....do...	98, 000	7, 350, 000

Total tonnage, 342,212 tons.

No new transportation lines established.

Total value of exports and imports and customs duties.

Years.	Total value.	Customs duties.
1888.....	$21, 102, 189	$35, 016. 45
1889.....	20, 246, 664	20, 278. 50

Statement of vessels of 100 *tons and over at the port of Wilmington for the years ending December* 31, 1888 *and* 1889.

	1888.		1889.	
	Vessels.	Tons.	Vessels.	Tons.
American	239	116, 818	232	115, 933
Foreign	131	68, 825	153	75, 097
	370	185, 643	385	191, 030

Entrances, clearances, and vessels documented for years ending December 31, 1888 *and* 1889.

	1888.	1889.
Foreign:		
Entrances	131	153
Clearances	128	161
American:		
Entrances	239	232
Clearances	235	240
Vessels documented	61	61

Tonnage.

Vessels.	Foreign.		American.		Total.	
	1888.	1889.	1888.	1889.	1888.	1889.
Steamers	26, 083	26, 697	76, 567	72, 743	102, 650	99, 440
Ships	1, 154	.....	.....	.....	1, 154	.....
Barks	36, 633	41, 354	962	507	37, 595	41, 861
Brigs	4, 328	4, 883	2, 273	1, 233	6, 601	6, 116
Schooners	627	2, 163	37, 016	41, 450	37, 643	43, 613
Total	68, 825	75, 097	116, 818	115, 933	185, 643	191. 030

The above tables as to entrances, clearances, and tonnage embrace only vessels of 100 tons and upwards. No record has been kept of the numerous smaller vessels, whose tonnage may be estimated at least 20,000 tons.

M 13.

IMPROVEMENT OF YADKIN RIVER, NORTH CAROLINA.

HISTORY OF OPERATIONS.

(1) *Reference to past reports.*—For special description, see pages 626–648, Annual Report for 1879, and also pages—Appendix 19, Examinations and Surveys, Annual Report for 1888; for map of river and location of obstructions, see page 864, Annual Report of 1883.

(2) *Original condition.*—The Yadkin River, North Carolina (the upper end of the Great Pee Dee River), has a total length of about 215 miles and a drainage area of 4,320 square miles. Its middle third, extending from the railroad bridge near Sa'isbury 64½ miles upward to the foot.

of Bean Shoal, is the only portion so far under improvement by the General Government.

When placed under governmental improvement, in 1880, this portion of the Yadkin River had a slope of 2 feet to the mile, had its navigation completely obstructed by rock ledges, fish and mill dams, and numerous shoals, and had as little as 1 foot maximum depth at ordinary low water on some of its shoals and ledges. Its river commerce was nothing.

(3) *Plan of improvement.*—The original project of 1879 proposed to secure a 2.5 to 3-foot steam-boat navigation during the entire year over the 64½ miles above the Salisbury Railroad Bridge. The total final cost of the work necessary to secure the desired depth during only mean winter stages of water (two-thirds of the year) was estimated, in 1887, at $400,000.

A personal examination of the river over the 33 miles above the Salisbury Railroad Bridge in 1886–'87 showed the agricultural richness of the river-basin and its urgent need for transportation facilities.

The aggregate amount appropriated for this project up to June 30, 1890, is $97,000.

(5) *Results.*—Up to June 30, 1889, a total of $92,107.75 has been spent, in all, upon this improvement in securing a good channel for flat-boats (and an indifferent channel for steam-boats) of 40 to 70 feet width and from 2 to 2½ feet depth during mean winter stages of water (eight months of the year), from the Salisbury Railroad Bridge 33 miles upward, to Bailey's Ferry.

No river commerce had yet been created, and none was expected until the improvement was completed in good shape to Bailey's Ferry.

The navigation of the river within these 64 miles was not obstructed by bridges without draws.

(5) *Work of past year.*—The special work of the past year is as follows: Expenditures, $4,342.73; value of United States plant, $3,900.00.

The main work, resumed May 9, 1889, was suspended October 20, 1889, on account of the near exhaustion of funds.

During the working season 3 hoisters, 10 stone-flats, 2 quarter-boats, 3 other flats and other plant were in use.

The work was considerably interfered with by freshets.

Owing to its varied character and to the difficulty of estimating it beforehand and measuring it up afterwards, the work was, for advantage and economy, allowably done by hired labor and the purchase of materials in open market.

At ledge No. 18, 25 miles above the Salisbury Railroad Bridge, 4 cubic yards of rock were removed from the channel.

At ledge No. 17, 24 miles above the railroad bridge, 17 cubic yards of rock were removed from the channel.

At Oak's Ferry, 23 miles above the railroad bridge, 105 cubic yards of gravel were removed from the channel, 16 cubic yards from the shore end of the dam, and together with 7 cubic yards brought from ledge No. 17 were built into 24 linear feet of dam at its channel end, extending the dam and leaving a small gap at the shore end, so as not to interfere with the tail-race of a neighboring mill.

At Swicegood's Mill, 22 miles above the railroad bridge, 44 cubic yards of stone were blasted and removed from the channel, 41 cubic yards were taken from parts of the dam where not needed, 93 cubic yards were taken from other dikes where not needed, 60 cubic yards quarried elsewhere, and the whole 238 cubic yards of stone, together

with 7 cords of brush, were built into 12 linear feet of wing-dam and 268 linear feet of training-dike.

Twelve trees were cut and pulled back from the banks.

At Big Rock Shoal, 18 miles above the railroad bridge, 9 cubic yards of stone were blasted and removed from the channel.

At Barnes's Shoal (Shoal No. 13), 16 miles above the railroad bridge, 46 cubic yards of stone were blasted and removed from the channel, 183 cubic yards were quarried from the banks, 105 cubic yards were taken from other parts of the dikes where not needed, and 314 cubic yards of this stone were built into 303 linear feet of wing-dams and training-walls.

When work was suspended, October 20, 1889, six stone-boats, loaded with 10 cubic yards of stone, were sunk for storage, in shoal water, at Barnes's Shoal; the remainder of the United States plant was laid up and watched at Fulton's Ferry, 26 miles above the railroad bridge.

During the night of July 18, 1889, the water till then having stood at its ordinary stage and no rain having fallen at the works during the day, the river rose suddenly 6 feet, tearing one hoister, one blacksmith and carpenter's shop, and one stone-scow from their moorings. The shop flat was overturned, wrecked, and most of the tools were lost; the stone-scow was also lost; the hoister was finally secured and tied up about 1½ miles down-stream. The other hoisters and flats did not leave their moorings. The plant was at work at a specially-bad part of the river, and where a freshet might easily have done severe damage even in broad daylight. The loss from this accident, the only special one on this river during nine years' work, was less than $500 (12 per cent. of the value of the entire plant in use on the river), and seems to have been almost, if not quite, unavoidable.

Inspections of plant and work were made during the year.

Water-gauges have been kept during the year.

The work of this improvement during the year has been very efficiently carried on under the immediate supervision of Assistant Engineer Charle Humphreys and Superintendent Frank Brown, whose reports are herewith appended.

The work of the past year has finished the removal of the worst rock obstructions and left a fairly well-cleared channel everywhere at least 60 feet wide and at least 2.5 feet deep at ordinary low water from Bailey's Ferry (33 miles above the railroad bridge, 17 miles, down to Barnes's Shoal (16 miles above the railroad bridge). The river below Barnes's Shoal still needs much work.

The latest reliable commercial statistics, those for the year ending December 31, 1889, are herewith appended.

(6) *Recommendations for future work.*—It is recommended that this improvement be completed in accordance with the existing projects only so far as to secure a cleared channel-way of 60 feet available width and 2.5 to 3 feet clear depth at average winter water (eight months of the year) from the railroad landing close to and just below the Salisbury Railroad Bridge, 33 miles, up to Bailey's Ferry, at an expense of $10,000, in addition to the funds on hand on June 30, 1890, this amount to be appropriated at once in a single sum. Smaller appropriations will involve the alternate disorganization and reorganization of working parties, damage to unfinished work, deterioration of plant, and extra superintendence and care of property, and may increase the cost from $2,000 to $6,000 per year. Further improvement so as to extend this navigation over the remaining 30 miles is not recommended until the develop-

ment of a reasonable commerce on the lower 33 miles shall show the worthiness of further improvement.

This recommended improvement, once thoroughly finished, should be comparatively permanent.

This river is in the fifth collection district of North Carolina.

Money statement.

July 1, 1889, amount available		$4,892.25
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	4,169.73	
July 1, 1890, outstanding liabilities	173.00	
		4,342.73
July 1, 1890, balance available		549.52
Amount appropriated by act of September 19, 1890		5,000.00
Amount available for fiscal year ending June 30, 1891		5,549.52
Amount (estimated) required for completion of existing project		5,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		5,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

REPORT OF MR. FRANK BROWN, SUPERINTENDENT.

UNITED STATES ENGINEER OFFICE,
Mocksville, N. C., June 30, 1890.

CAPTAIN: I have the honor to submit the following report of operations upon the improvement of the Yadkin River, North Carolina, for the year ending June 30, 1890.

The work consisted in trimming up or improving the channel previously worked, having, for my guide, blue prints issued from your office May 15, 1889. Owing to much high water and several extraordinary freshets, work could not be pushed forward with much satisfaction. During one of these very sudden rises in the river—caused by a cloud-burst some 60 or 70 miles up the river—we sustained the loss of the blacksmith shop and one stone-boat, together with a number of tools. The plant will need considerable repairs before beginning work this coming season.

Work begun at Ledge No. 17 and closed after having finished "Barnes's Shoal." The plant now lies in winter quarters at Fulton.

The work for the fiscal year beginning July 1, 1889, and ending June 30, 1890, is as follows:

Trees cut from bank	12
Cubic yards of stone raised from the channel	120
Cubic yards gravel raised from the channel	105
Cubic yards of stone sunk in dams	574
Cubic yards of stone quarried and brought from borrow pits	243
Cubic yards of stone raised from dams	255
Cords of brush collected and sunk in dams	7
Linear feet of wing-dams	357
Linear feet of training-walls built	250
Linear feet of drilling	482
Number of blasts with drilling	144
Number of blasts without drilling	30

Very respectfully, your obedient servant,

FRANK BROWN,
Superintendent.

Capt. W. H. BIXBY,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

When work commenced in 1880 there was no navigable channel on account of obstructing shoals, rock ledges, and mill-dams, and consequently no commerce.

At present an indifferent channel of from 40 to 70 feet width and 2½ feet depth during the flush-water season has been secured from the North Carolina Railroad bridge,

SHEET I

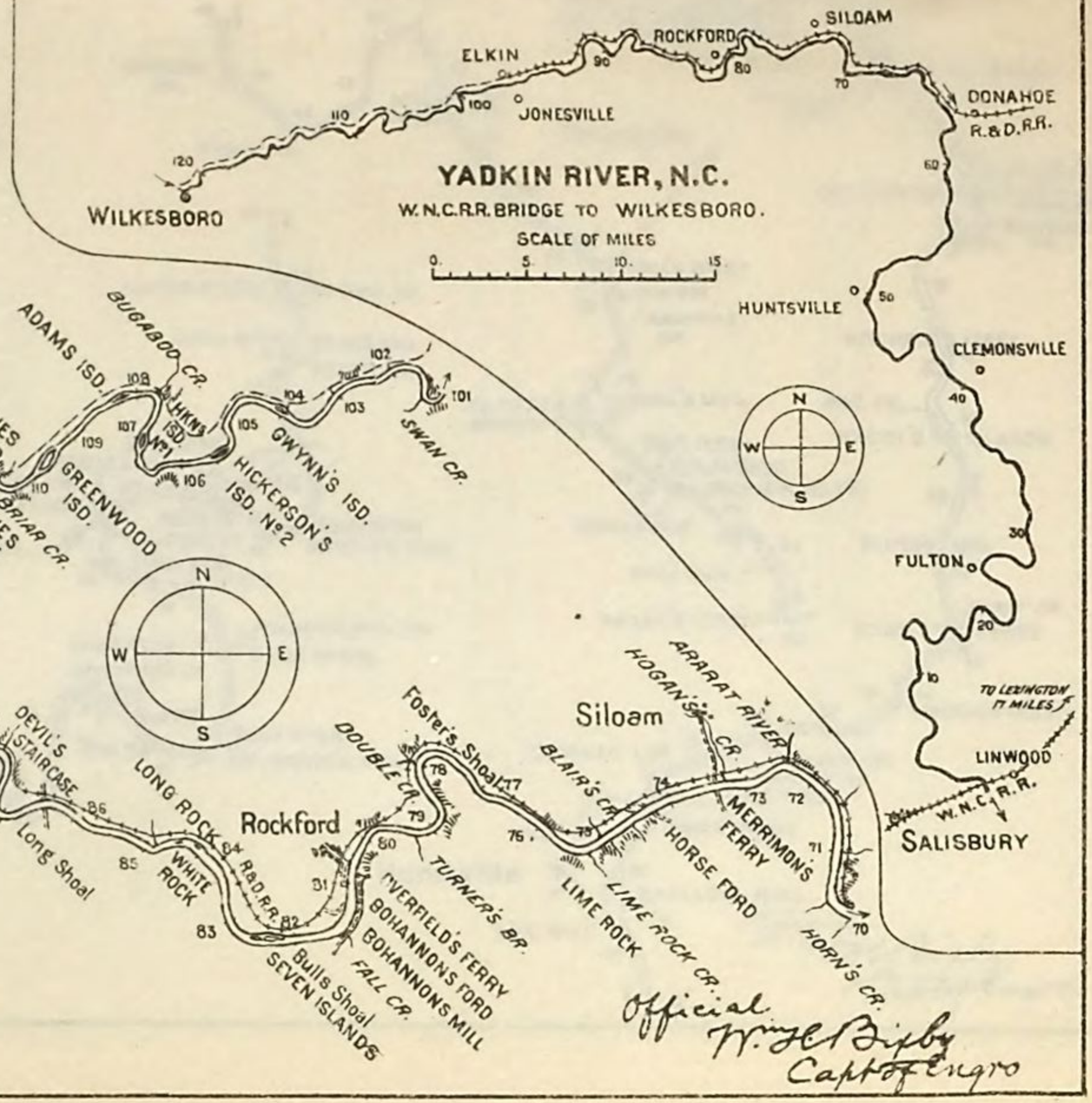
YADKIN RIVER, N.C.

FROM W.N.C.R.R. BRIDGE NEAR SALISBURY TO WILKESBORO

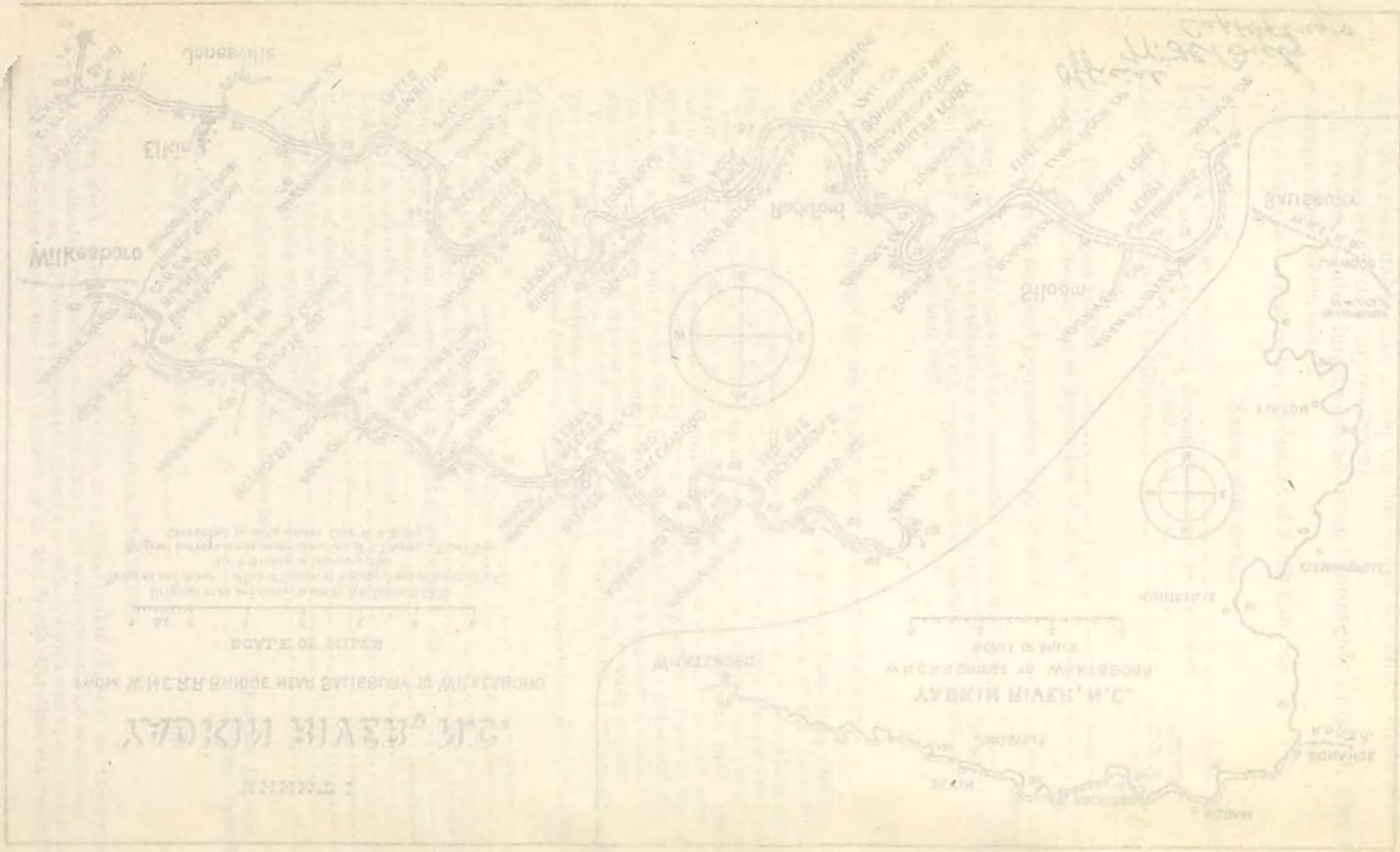
SCALE OF MILES

1 0.5 0 1 2 3 4 5

Original map and survey made by S.W. Evans in 1878
Reduced and drawn in office of Captain W. H. Bixby, Corps of Engrs. U.S.A.
by P. Brosig in February 1890.
Original surveys made under direction of S.T. Aberi, U.S. Civil Engr.
Corrected to date under Capt. W. H. Bixby.



Official
W. H. Bixby
Capt of Engrs



SHEET 2

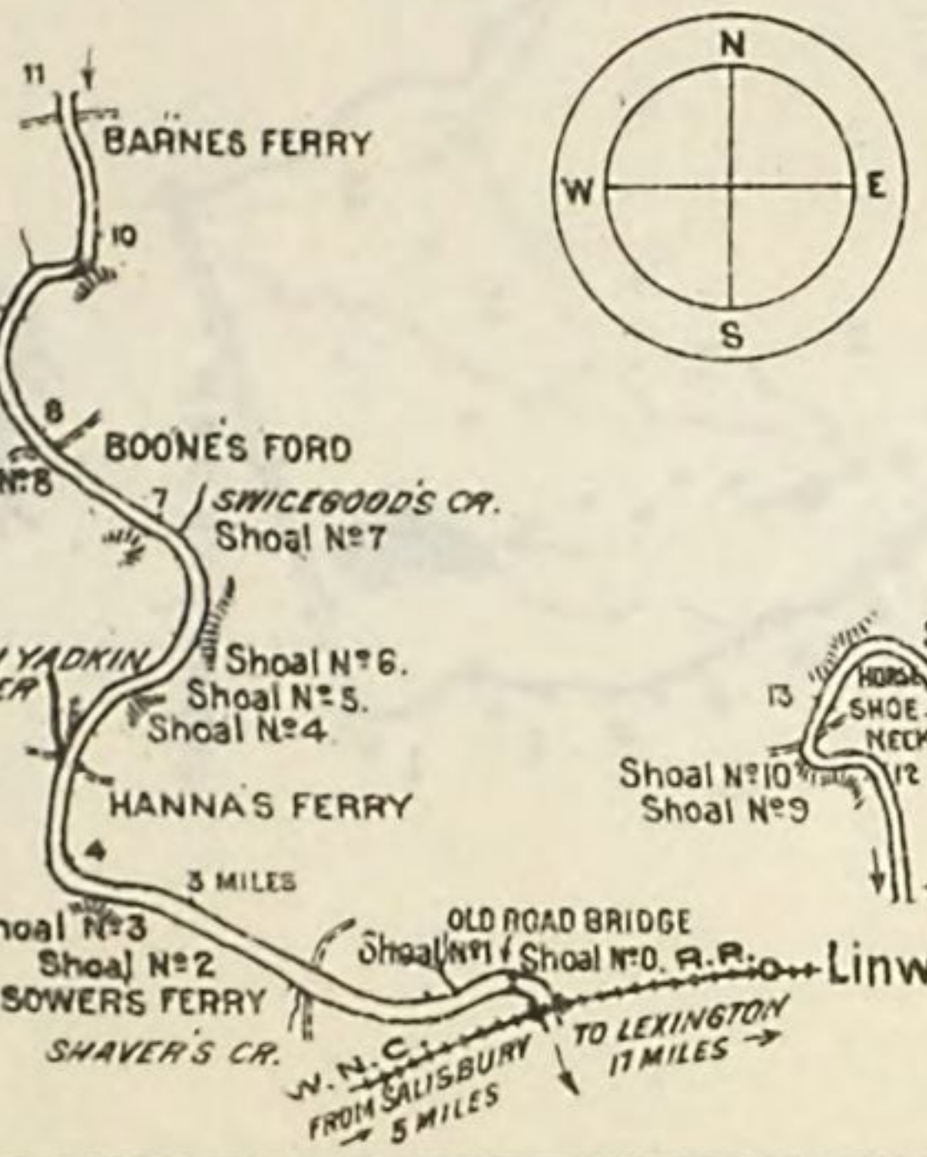
YADKIN RIVER, N.C.

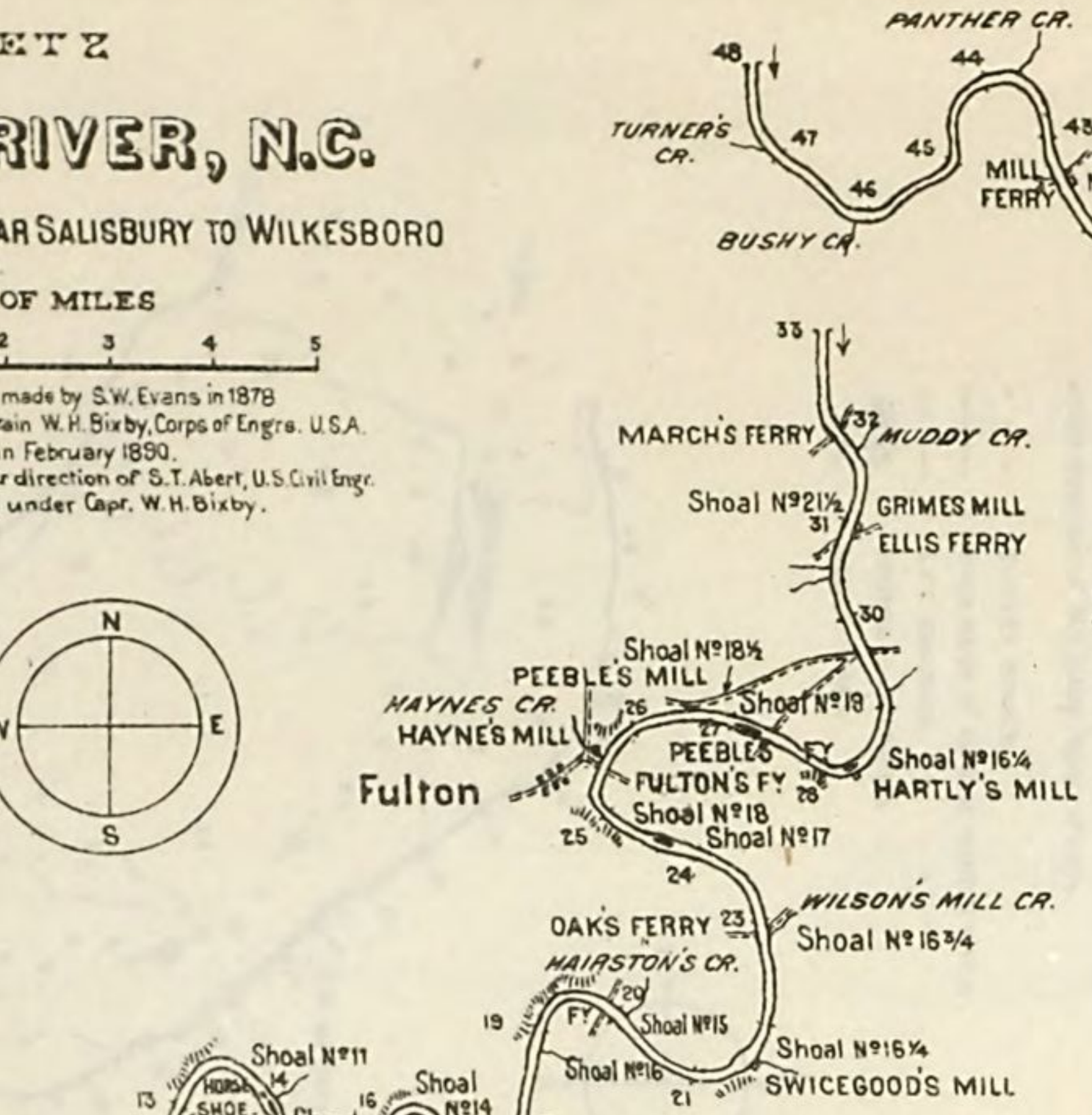
FROM W.N.C.R.R. BRIDGE NEAR SALISBURY TO WILKESBORO

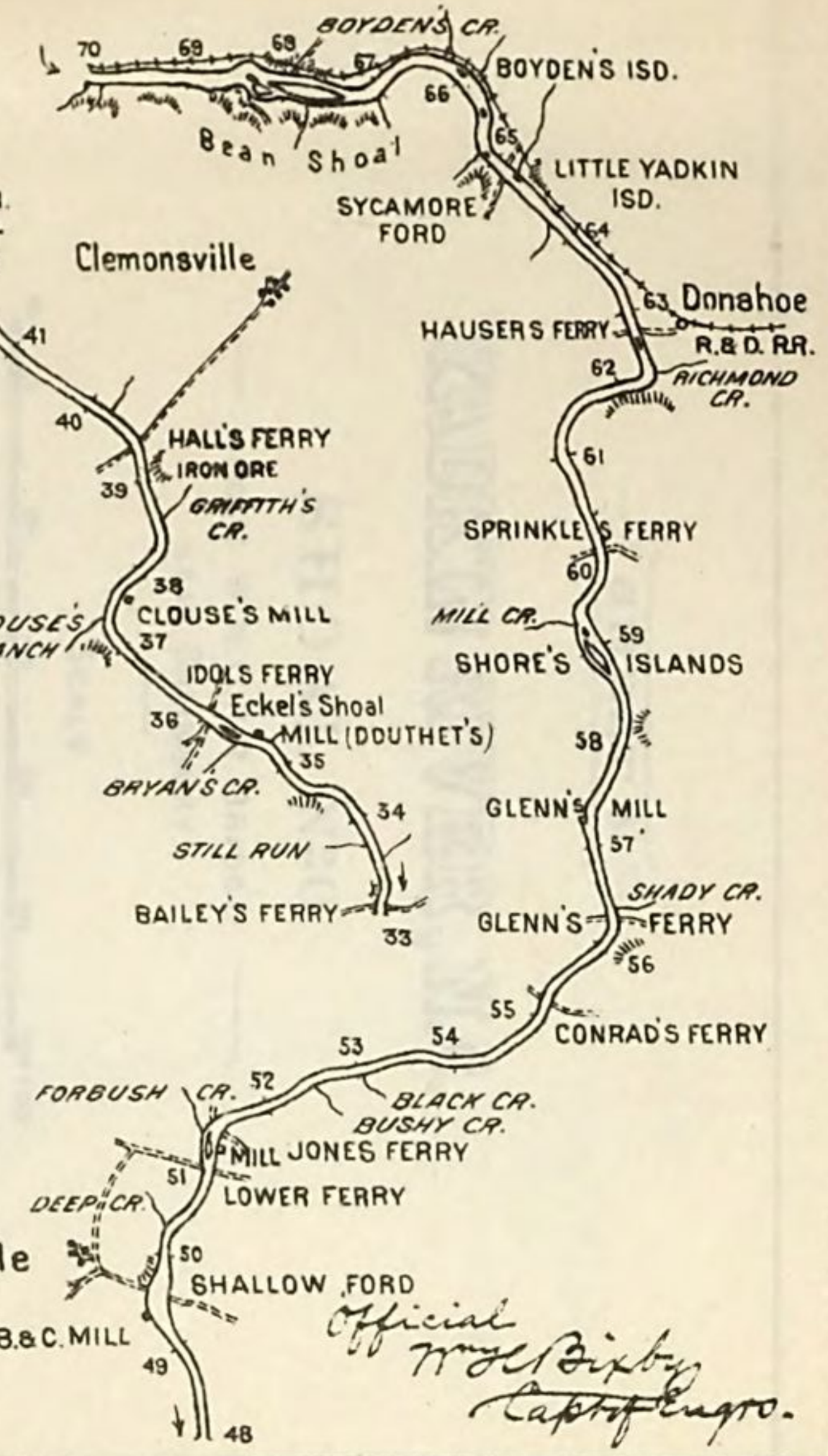
SCALE OF MILES

1 0.5 0 1 2 3 4 5

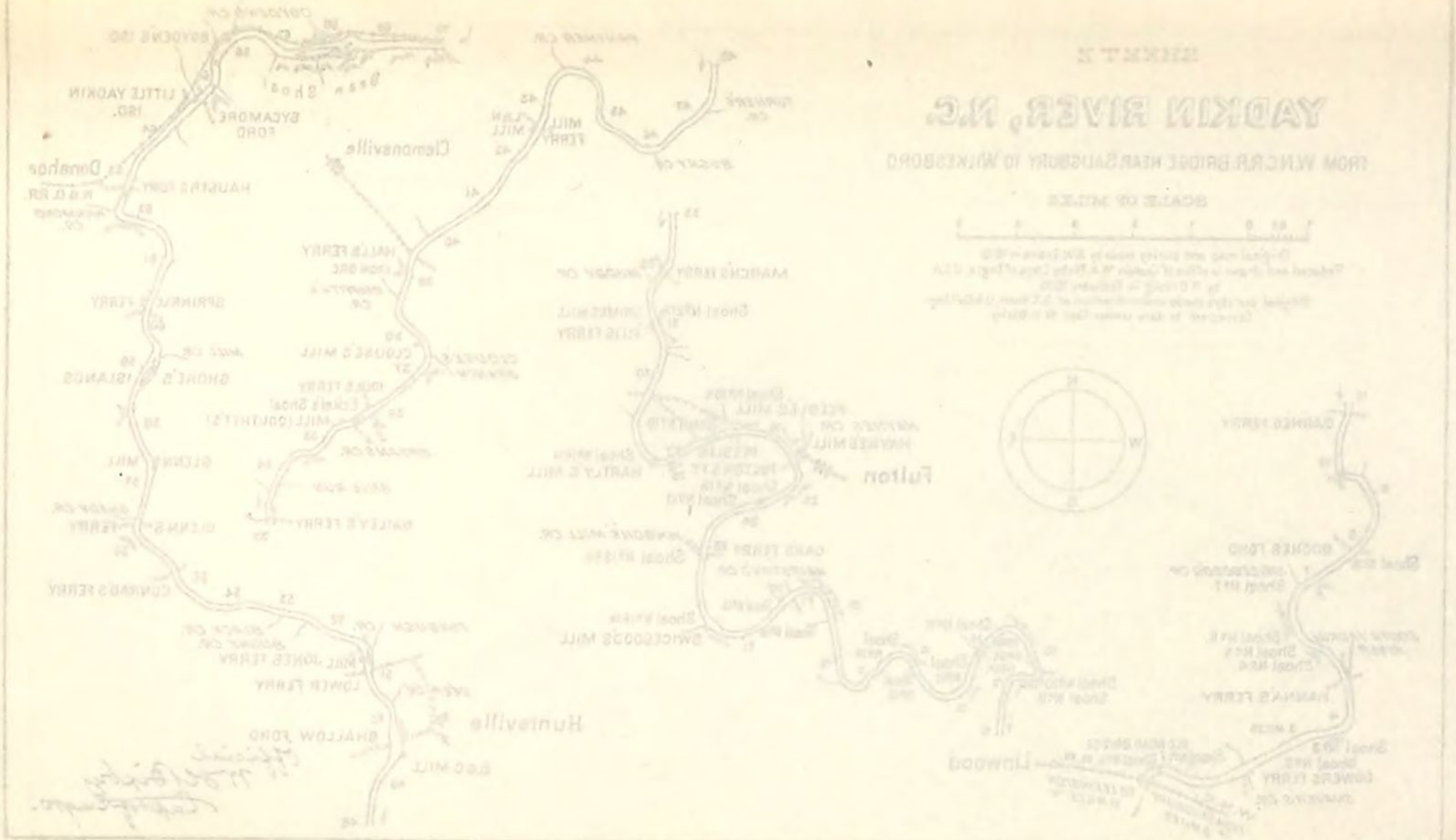
Original map and survey made by S.W. Evans in 1878
Reduced and drawn in office of Captain W. H. Bixby, Corps of Engrs. U.S.A.
by P. Brosig in February 1890.
Original surveys made under direction of S.T. Abert, U.S. Civil Engr.
Corrected to date under Capt. W.H. Bixby.







Official
Wm. H. Bixby
Capt. Engrs.


Clemonsville
Fulton
Hunsville

SHEET 3

YADKIN RIVER, N.C.

SHOAL Nº0

ABOVE W.N.C.R.R. BRIDGE

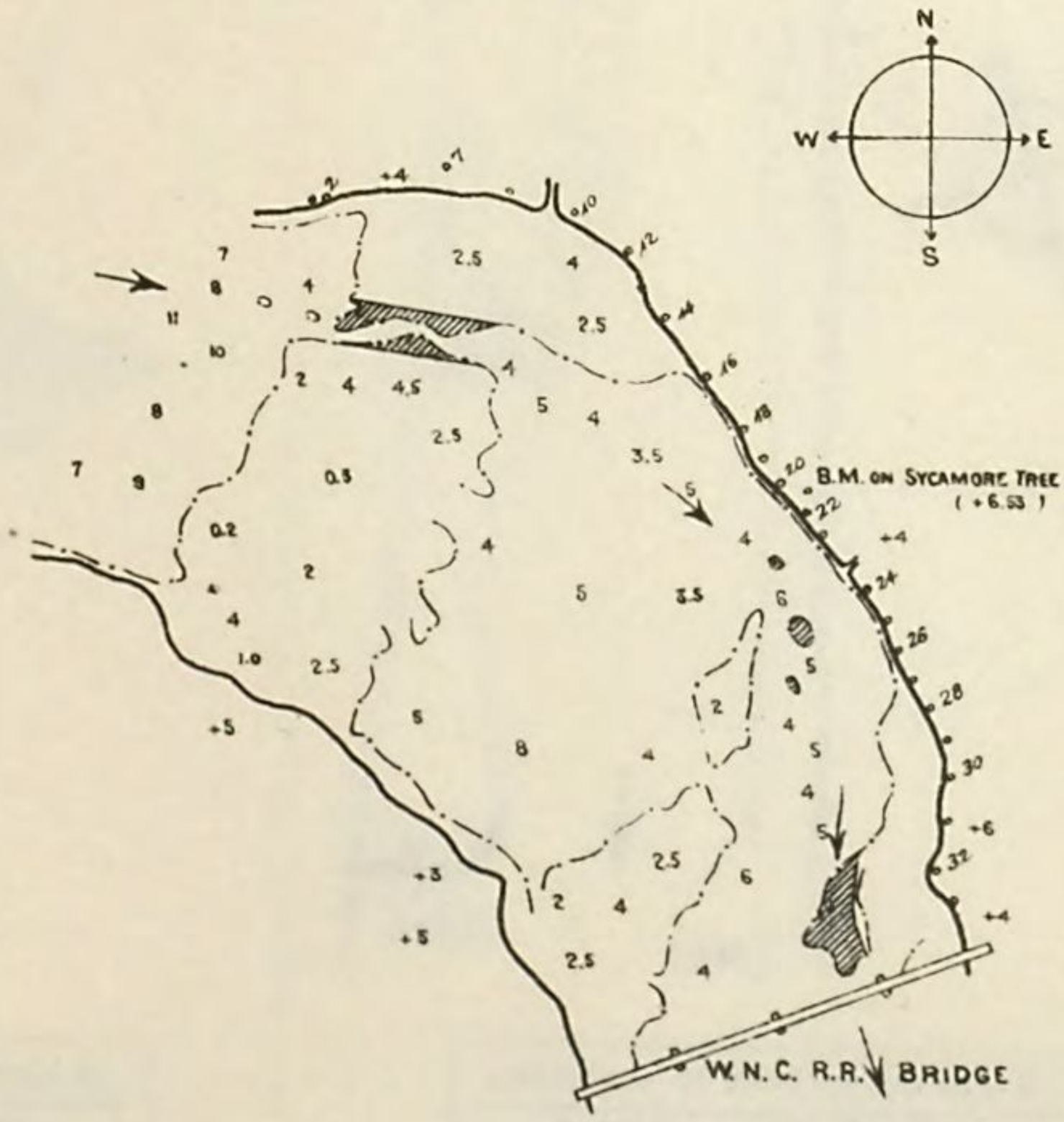
NEAR SALISBURY

SCALE

100 0 200 400 600 800 1000 FEET

Based on survey of 1888 by H. Taylor, 1st Lt. Corps of Engrs.
under direction of W.H. Bixby, Captain of Engrs.

- ° ° ° = SURVEY STAKES
- ——— = RIVER BANK AT AVERAGE WINTER WATER.
- —·— = 3 FT. CONTOUR " " " "
- ////// = PROPOSED DREDGING
- B.M. = BENCH MARK



Official
W. H. Bixby
Capt of Engrs.

DRAWN BY P. BROSIC

Eng 90

N
W
E
S

SHEET 4.

YADKIN RIVER, N.C.

Outline Map
OF

SHOALS AND MILL DAMS
AND

U.S. WORKS THEREAT

JUNE 1890

as surveyed and plotted by
Chas. Humphreys, Asst. Engineer
— under direction of —
W. H. Bixby,
Captain of Engineers, U.S. Army.

SCALE OF FEET

100 50 0 100 200 300 400 500 FT.

= SHORE LINE AS SURVEYED
= SHORE LINE AS ESTIMATED
= ROCK LEDGES
= 3 FT. CURVE AT LOW WATER
= SURVEY STAKES
= DIKES, JETTIES OR DAMS
= PROPOSED DREDGING OR BLASTING
= PROPOSED DIKES
(1.50) (2.35) = WATER SURFACE ELEVATION IN FEET.
(1882) (1890) = YEAR OF CONSTRUCTION OF DIKES

Official W. H. Bixby Capt. Engrs.

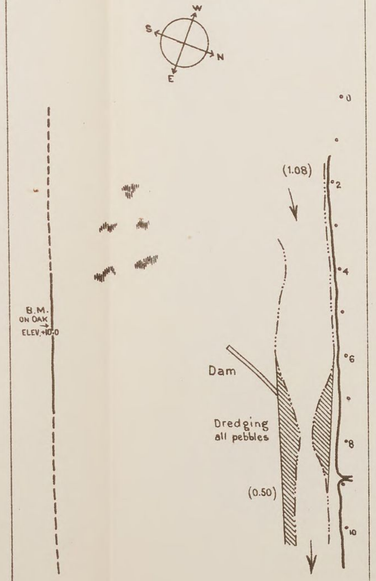
DRAWN BY P. BROSIA.

SHOAL No. 1

0.5 MILES ABOVE W.N.C.R.R. BRIDGE

Surveyed 18 Nov. 1888 when water stood at 1.35 ft. above low winter water.

Least Channel Depth - 2.7 ft. at low winter water.

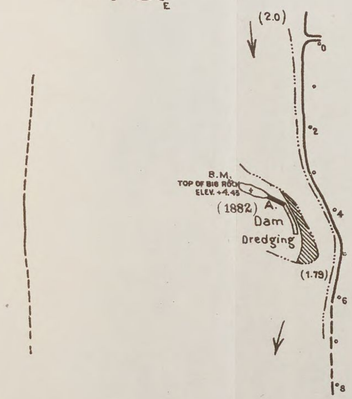


SHOAL No. 2
CALLED
BIG ROCK SHOAL

2.2 MILES ABOVE W.N.C.R.R. BRIDGE

Surveyed 15 Nov. 1888 when water stood at 1.8 ft. above low winter water.

Least Channel Depth - 2.5 ft. at low winter water.



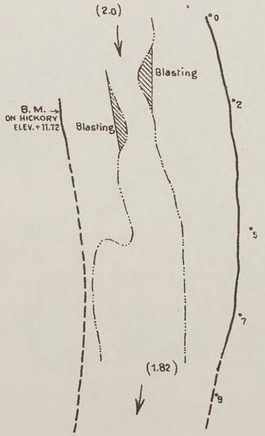
LENGTHS OF EXISTING DIKES &c.
A. 45 feet.

SHOAL No. 3
CALLED
DEEP HOLE SHOAL

3.2 MILES ABOVE W.N.C.R.R. BRIDGE

Surveyed 15 Nov. 1888 when water stood at 1.2 ft. above low winter water.

Least Channel Depth - 3.0 ft. at low winter water.

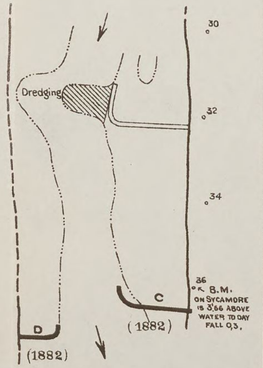


SHOAL No. 4
CALLED
CLINTON SHOALS

5.2 MILES ABOVE W.N.C.R.R. BRIDGE

Surveyed 15 Nov. 1888 when water stood at 1.1 ft. above low winter water.

Least Channel Depth - 2.9 ft. at low winter water.



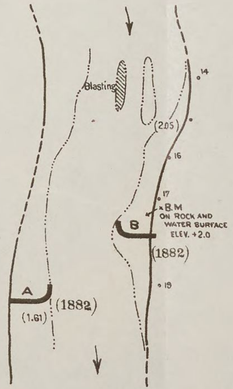
LENGTHS OF EXISTING DIKES &c.
C 210 Feet. D 110 Feet.
TOTAL 320 Feet.

SHOAL No. 5
CALLED
SIMMISON'S LOWER DAM SHOAL

5.6 MILES ABOVE W.N.C.R.R. BRIDGE

Surveyed 15 Nov. 1888 when water stood at 1.1 ft. above low winter water.

Least Channel Depth - 3.0 ft. at low winter water.



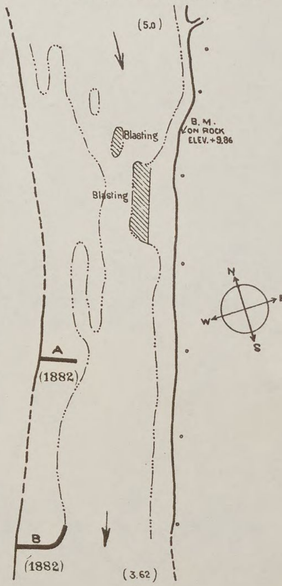
LENGTHS OF EXISTING DIKES &c.
A 130 Feet. B 120 Feet.
TOTAL 250 Feet.

SHOAL No. 6
CALLED
SIMMISON'S UPPER DAM SHOAL

6.2 MILES ABOVE W.N.C.R.R. BRIDGE

Surveyed 15 Nov. 1888 when water stood at 1.0 ft. above low winter water

Least Channel Depth - 2.0 ft. at low winter water.



LENGTHS OF EXISTING DIKES &c.
A 90 Feet. B 150 Feet.
TOTAL 240 Feet.

U.S. WORKS THEREAT

AND

SHOALS AND MILL DAMS

OF

Ontario Lake

JUNE 1880

SHEET 4

SHEET 5.

YADKIN RIVER, N.C.

Outline Map

OF

SHOALS AND MILL DAMS

U.S. WORKS THEREAT

JUNE 1890

as surveyed and plotted by
Chas. Humphreys, Asst. Engineer
under direction of
W. H. Bixby,
Captain of Engineers, U.S. Army.

SCALE OF FEET.

100 60 0 100 200 300 400 500 FT.

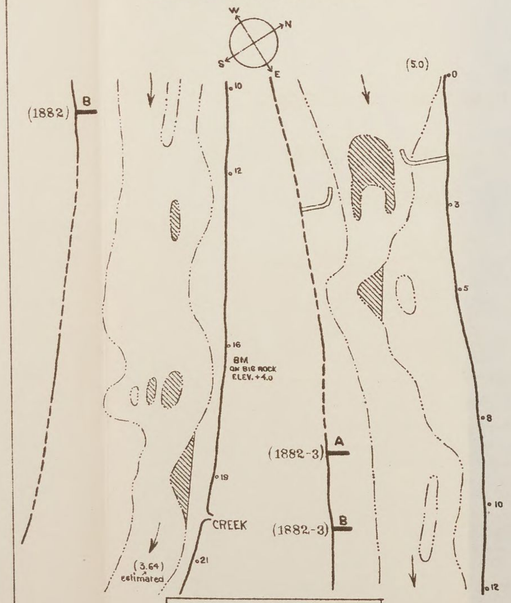
- = SHORELINE AS SURVEYED
- = SHORELINE AS ESTIMATED
- = ROCK LEDGES
- = 3 FT. CURVE AT LOW WATER
- = SURVEY STAKES
- = DIKES, JETTIES OR DAMS
- = PROPOSED DREDGING OR BLASTING
- = PROPOSED DIKES
- (1.50) (2.35) = WATER SURFACE ELEVATION IN FEET
- (1882) (1890) = YEAR OF CONSTRUCTION OF DIKES

Official W. H. Bixby
Capt. of Engrs.

DRAWN BY P. BROSIG.

SHOAL Nº 7
CALLED
SWICEGOOD'S CREEK SHOAL
6.2 MILES ABOVE W.N.C.R.R. BRIDGE

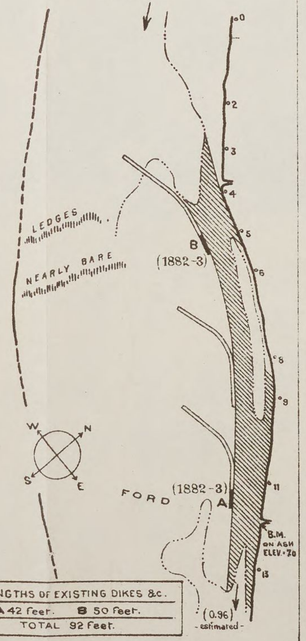
Surveyed 14. Nov. 1888,
when water stood at 1.0 ft. above low winter water.
Least Channel Depth = 2.2 ft. at low winter water



LENGTHS OF EXISTING DIKES &c.
A 52 Feet. B 48 Feet.
TOTAL 100 Feet.

SHOAL Nº 8
CALLED
BOONE'S FORD SHOAL
7.8 MILES ABOVE W.N.C.R.R. BRIDGE

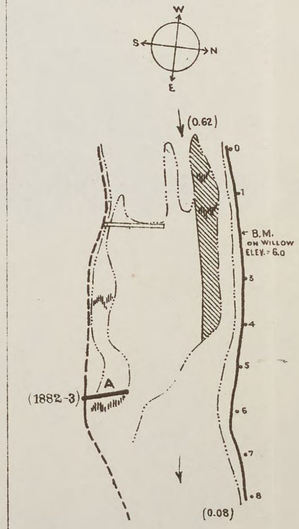
Surveyed 8. Nov. 1888
when water stood at 0.2 ft. above low winter water.
Least Channel Depth = 1.7 ft. at low winter water.
(2.27)



LENGTHS OF EXISTING DIKES &c.
A 42 Feet. B 50 Feet.
TOTAL 92 Feet.

SHOAL Nº 9
CALLED
CLICK'S FISH DAM SHOAL
12.0 MILES ABOVE W.N.C.R.R. BRIDGE

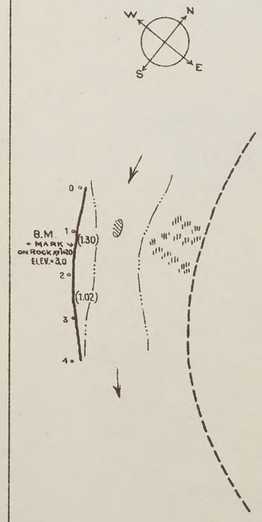
Surveyed 7. Nov. 1888
when water stood at 0.2 ft. above low winter water.
Least Channe Depth 1.8 ft. at low winter water.



LENGTHS OF EXISTING DIKES &c.
A 110 Feet

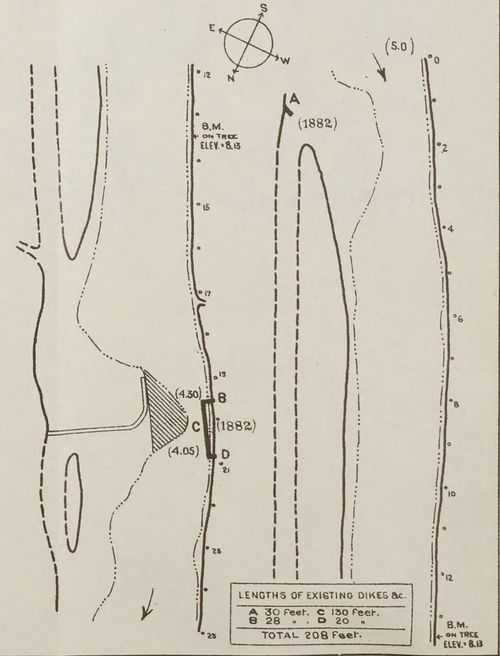
SHOAL Nº 10
CALLED
CLICK'S FERRY SHOAL
12.3 MILES ABOVE W.N.C.R.R. BRIDGE

Surveyed 7. Nov. 1888,
when water stood at 0.2 ft. above low winter water.
Least Channel Depth = 2.8 ft. above low w. water.



SHOAL Nº 11
CALLED
DUTCHMAN'S ISLAND SHOAL
14.1 MILES ABOVE W.N.C.R.R. BRIDGE

Surveyed 5. Nov. 1888,
when water stood at 0.2 ft. above low winter water.
Least Channel Depth = 2.3 ft. at low winter water.



LENGTHS OF EXISTING DIKES &c.
A 30 Feet. C 130 Feet.
B 28 " D 20 "
TOTAL 208 Feet.

Eng 90

SHEET 2

SHEET 6.

YADKIN RIVER, N.C.

Outline Map

OF

SHOALS AND MILL DAMS

AND

U.S. WORKS THEREAT

JUNE 1890

as surveyed and plotted by
Chas. Humphreys, Asst. Engineer
under direction of
W. H. Bixby,
Captain of Engineers, U.S. Army.

SCALE OF FEET

100 50 0 100 200 300 400 500 FT.

- ——— = SHORE LINE AS SURVEYED
- - - - - = SHORE LINE AS ESTIMATED
- = ROCK LEDGES
- ——·—— = 3 FT. CURVE AT LOW WATER
- ° ° = SURVEY STAKES
- = DIKES, JETTIES OR DAMS
- = PROPOSED DIKES
- (1.50) (2.35) = WATER SURFACE ELEVATION IN FEET
- (1882) (1890) = YEAR OF CONSTRUCTION OF DIKES

Official W. H. Bixby Capt of Engrs

DRAWN BY P. BROSIG.

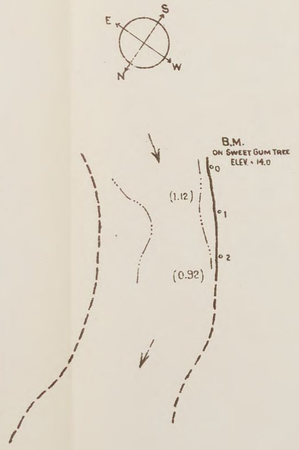
SHOAL Nº 12

CALLED

BULL HOLE SHOAL

14.8 MILES ABOVE W.N.C.R.R. BRIDGE

Surveyed 7. Nov. 1888,
when water stood at 0.2 ft. above low winter water
Least Channel Depth = 2.8 ft. at low winter water



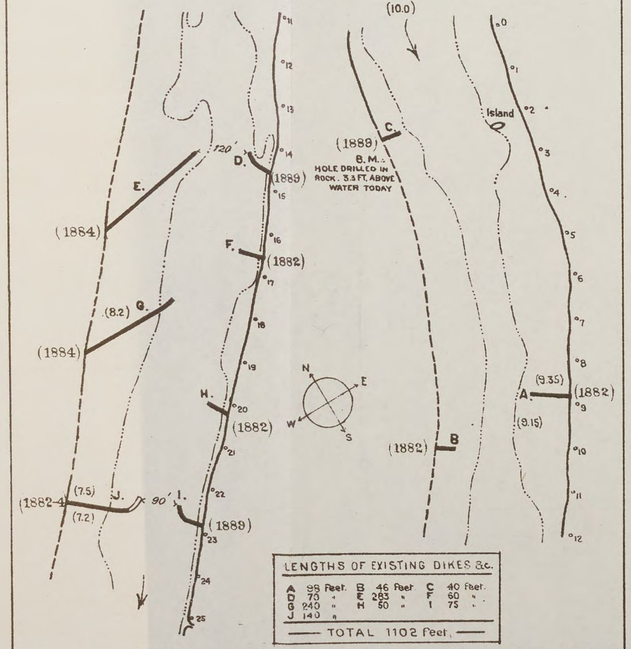
SHOAL Nº 13

CALLED

BARNE'S FISH TRAP SHOAL

16.0 MILES ABOVE W.N.C.R.R. BRIDGE.

Surveyed 3 & 5. Nov. 1888,
when water stood at 0.3 Ft. above low winter water.
Least Channel Depth = 1.9 ft. at low winter water, in 1888.
3.0 Ft. " " " " 1890.



LENGTHS OF EXISTING DIKES &c.

A	98 Feet.	B	46 Feet	C	40 Feet.
D	70 "	E	283 "	F	60 "
G	240 "	H	50 "	I	75 "
J	140 "				

TOTAL 1102 Feet.

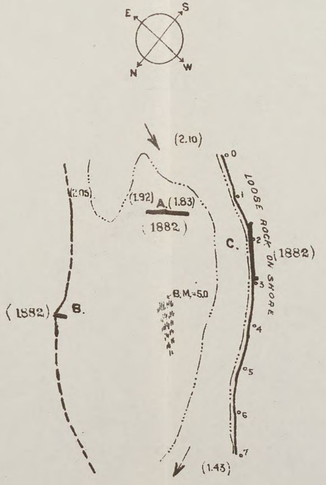
SHOAL Nº 14

CALLED

BIG ROCK SHOAL

16.6 MILES ABOVE W.N.C.R.R. BRIDGE

Surveyed 3 Nov. 1888
when water stood at 0.4 ft. above low winter water.
Least Channel Depth = 2.6 ft. at low winter water, in 1888.
3.0 ft. " " " 1890.



LENGTHS OF EXISTING DIKES &c.

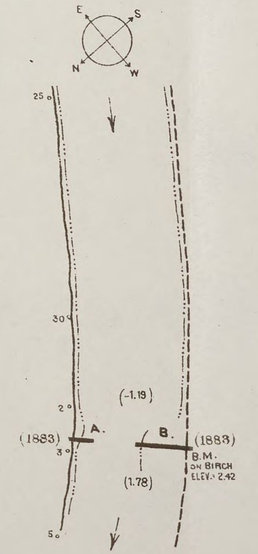
A 110 Feet. B 35 Feet C 140 Feet.

TOTAL 285 Feet.

SHOAL Nº 15

20.3 MILES ABOVE W.N.C.R.R. BRIDGE

Surveyed 2 Nov. 1888
when water stood at 0.5 Ft. above low winter water
Least Channel Depth = 3.0 ft. at low winter water.



LENGTHS OF EXISTING DIKES &c.

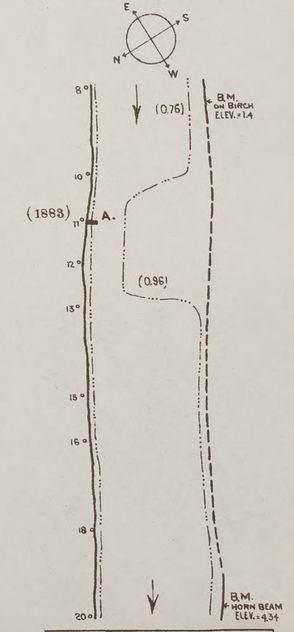
A 55 Feet. B. 135 Feet.

TOTAL 190 Feet.

SHOAL Nº 16

20.7 MILES ABOVE W.N.C.R.R. BRIDGE

Surveyed 1 & 2 Nov. 1888
when water stood at 0.6 ft. above low winter water.
Least Channel Depth = 2.6 ft. at low winter water, in 1888.
3.0 ft. " " " 1890.



LENGTHS OF EXISTING DIKES &c.

A, 25 Feet.

U.S. WORKS THEREAT

SHOALS AND MILL DAMS

OF

Portland Maine

JUNE 1880

ANDREW MCALEER, M.C.

SHEET 2

SHEET 1.

YADKIN RIVER, N.C.

Outline Map

OF

SHOALS AND MILL DAMS

AND

U.S. WORKS THEREAT

as Surveyed and plotted by
Chas. Humphreys, Asst. Engineer
— under direction of —
W. H. Bixby,
Captain of Engineers, U.S. Army.

SCALE OF FEET.

100 50 0 100 200 300 400 500 FT.

- ——— = SHORE LINE AS SURVEYED
- - - - - = SHORE LINE AS ESTIMATED
- = ROCK LEDGES
- ——·—— = 3 FT. CURVE AT LOW WATER
- ° ° ° = SURVEY STAKES
- = DIKES, JETTIES OR DAMS
- = PROPOSED DIKES
- = SUBMERGED DIKE OR SILL
- (1.50) (2.35) = WATER SURFACE ELEVATION IN FEET
- (1882) (1890) = YEAR OF CONSTRUCTION OF DIKES

Official W. H. Bixby
Capt. of Engrs.

DRAWN BY P. BROSIG.

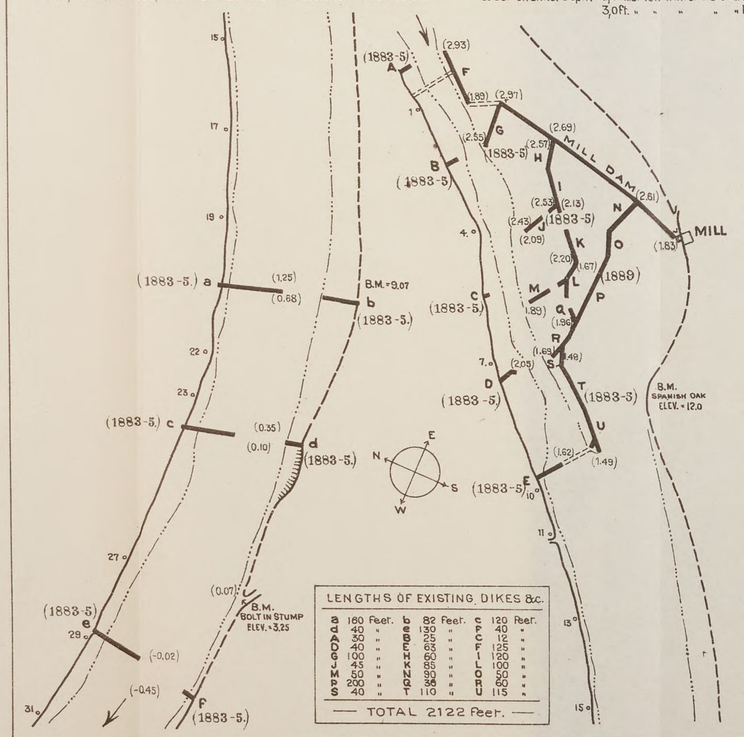
SHOAL No 16¼

CALLED

SWICEGOOD'S MILL SHOAL

21.5 MILES ABOVE W.N.C.R.R. BRIDGE

Surveyed 1. Nov. 1888, when water stood at 1.1 ft. above low winter water. Least Channel Depth = 2.5 ft. at low winter water in 1888.
3.0 ft. " " " " " 1890.



LENGTHS OF EXISTING DIKES &c.

a	160 Feet.	b	82 Feet.	c	120 Feet.
d	40 "	e	130 "	f	40 "
A	30 "	B	25 "	C	12 "
D	40 "	E	65 "	F	125 "
G	100 "	H	80 "	I	120 "
J	45 "	K	85 "	L	100 "
M	50 "	N	90 "	O	50 "
P	200 "	Q	30 "	R	60 "
S	40 "	T	110 "	U	115 "

TOTAL 2122 Feet.

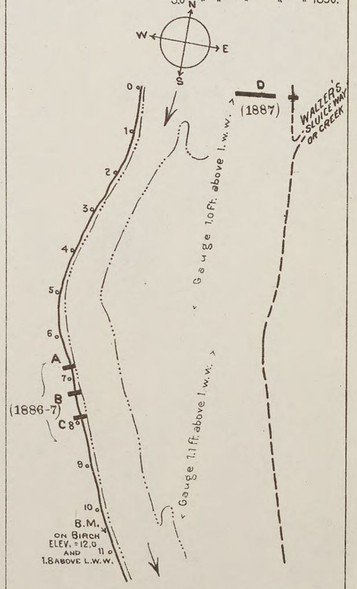
SHOAL No 16¾

CALLED

OAK'S FERRY SHOAL

22.7 MILES ABOVE W.N.C.R.R. BRIDGE

Surveyed 24. Oct. 1888,
when water stood at 1.1 & 1.0 ft. above low winter water.
Least Channel Depth = 1.7 ft. at low winter water. in 1888.
3.0 " " " " " 1890.



LENGTHS OF EXISTING DIKES &c.

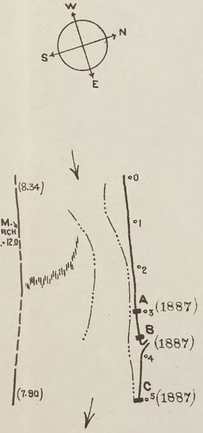
A	27 Feet.	C	21 Feet.
B	20 "	D	110 "

TOTAL 178 Feet.

SHOAL No 17

24.4 MILES ABOVE W.N.C.R.R. BRIDGE

Surveyed 22 Oct. 1888,
when water stood at 0.25 ft. above low winter water.
Least Channel Depth = 2.9 ft. at low winter water. in 1888.
3.0 " " " " " 1890.



LENGTHS OF EXISTING DIKES &c.

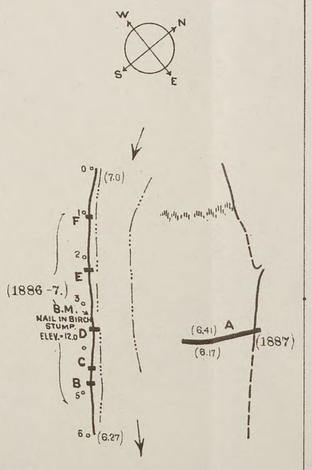
A 12 Feet B 13 Feet C 16 Feet.

TOTAL 41. Feet.

SHOAL No 18

24.8 MILES ABOVE W.N.C.R.R. BRIDGE

Surveyed 22 Oct. 1888
when water stood at 0.25 ft. above low winter water
Least Channel Depth = 2.7 ft. at low winter water in 1888.
3.0 ft. " " " " " 1890.



LENGTHS OF EXISTING DIKES &c.

A.	178 Feet.	D.	15 Feet.
B.	18 "	E.	25 "
C.	12 "	F.	10 "

TOTAL 258 Feet.

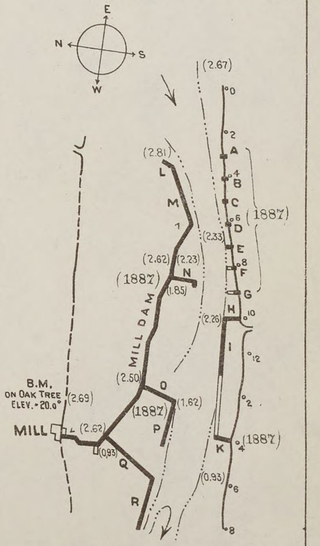
SHOAL No 18½

CALLED

PEEBLE'S MILL SHOAL

26.6 MILES ABOVE W.N.C.R.R. BRIDGE

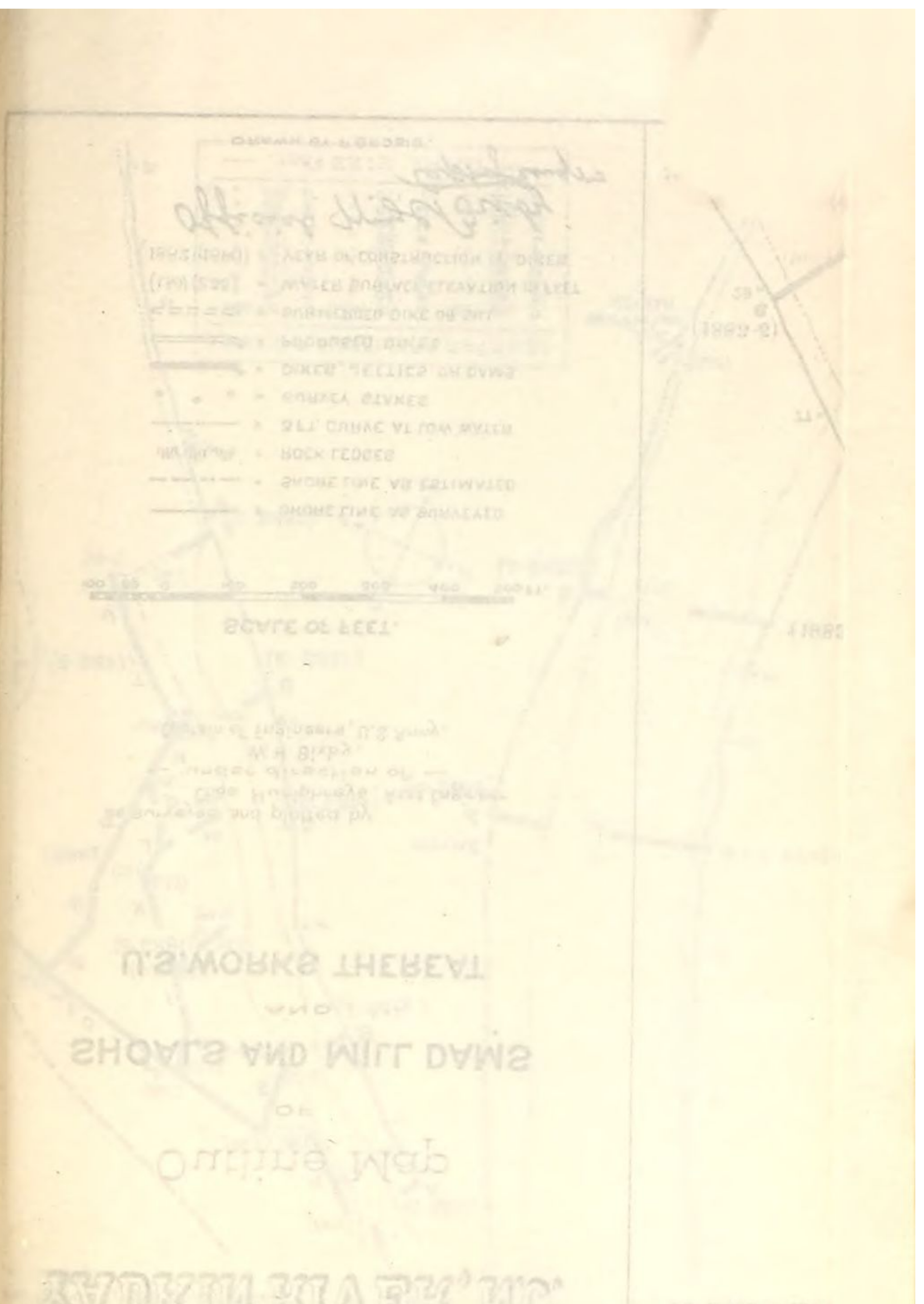
Surveyed 15 Oct. 1888,
when water stood at 0.7 ft. above low winter water
Least Channel Depth = 1.5 ft. at low winter water. in 1888
3.0 ft. " " " " " 1890.



LENGTHS OF EXISTING DIKES &c.

A	10 Feet.	B	10 Feet.	C	10 Feet.
D	10 "	E	10 "	F	10 "
G	10 "	H	40 "	I	130 "
K	50 "	L	33 "	M	140 "
N	65 "	O	80 "	P	110 "
Q	140 "	R	110 "		

TOTAL 968 Feet.



SHEET 8.

YADKIN RIVER, N.C.

Outline Map

OF

SHOALS AND MILL DAMS

AND

U.S. WORKS THEREAT

as surveyed and plotted by
Chas. Humphreys, Asst. Engineer
under direction of
W. H. Bixby,
Captain of Engineers, U.S. Army.

SCALE OF FEET

100 50 0 100 200 300 400 500 FT.

- ——— = SHORE LINE AS SURVEYED
- - - - - = SHORE LINE AS ESTIMATED
- = ROCK LEDGES
- = 3 FT. CURVE AT LOW WATER
- = SURVEY STAKES
- = DIKES, JETTIES OR DAMS
- = PROPOSED DIKES
- (150) (2.35) = WATER SURFACE ELEVATION IN FEET
- (1882) (1890) = YEAR OF CONSTRUCTION OF DIKES

Official W. H. Bixby Capt. of Engrs.

DRAWN BY P. BROSIG

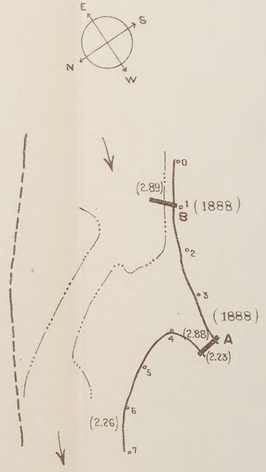
SHOAL Nº 19

CALLED

PEEBLE'S ISLAND SHOAL

MILES ABOVE W.N.C.R.R. BRIDGE

Surveyed 16 Oct. 1888,
when water stood at 1.3 Ft. above low winter water
Least Channel Depth = 3.0 Ft. at low winter water.



Channel cleared in 1888.

LENGTHS OF EXISTING DIKES &c.			
A	52 Feet.	B	57 Feet.
TOTAL 109 Feet.			

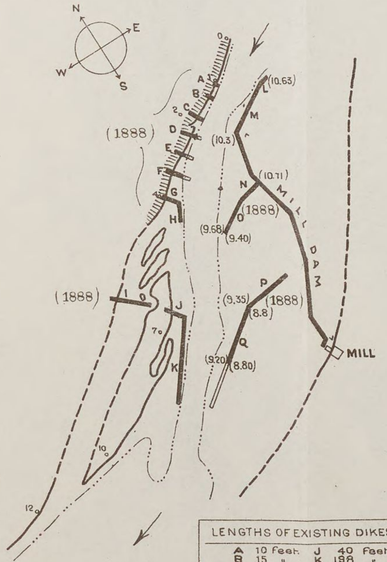
SHOAL Nº 19½

CALLED

HARTLY'S MILL SHOAL

28.3 MILES ABOVE W.N.C.R.R. BRIDGE

Surveyed 17 & 18 Oct. 1888,
when water stood at 0.4 Ft. above low winter water.
Least Channel Depth = 1.8 Ft. at low winter water. in 1888
3.0 Ft. " " " " " 1890

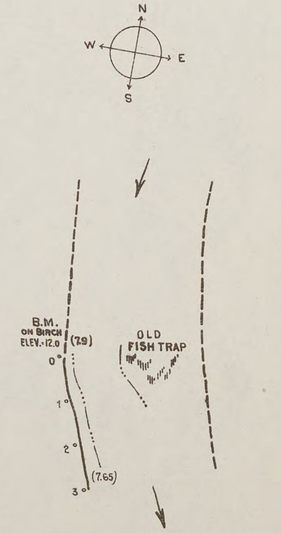


LENGTHS OF EXISTING DIKES &c.					
A	10 Feet.	J	40	Feet.	
B	15 "	K	198	"	
C	43 "	L	18	"	
D	46 "	M	132	"	
E	28 "	N	50	"	
F	45 "	O	90	"	
GH	67 "	P	110	"	
I	85 "	Q	132	"	
TOTAL 1109 Feet.					

SHOAL Nº 20

30.2 MILES ABOVE W.N.C.R.R. BRIDGE

Surveyed 19 Oct. 1888,
when water stood at 0.2 Ft. above low winter water.
Least Channel Depth = 3,0 Ft. at low winter water.

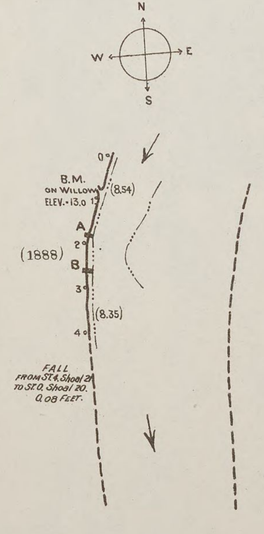


Channel cleared in 1888.

SHOAL Nº 21

30.4 MILES ABOVE W.N.C.R.R. BRIDGE

Surveyed 19 Oct. 1888,
when water stood at 0.2 Ft. above low winter water
Least Channel Depth = 3.0 Ft. at low winter water.



Blasting & Jetties finished in 1888.

LENGTHS OF EXISTING DIKES &c.			
A	29 Feet.	B	30 Feet.
TOTAL 59 Feet.			

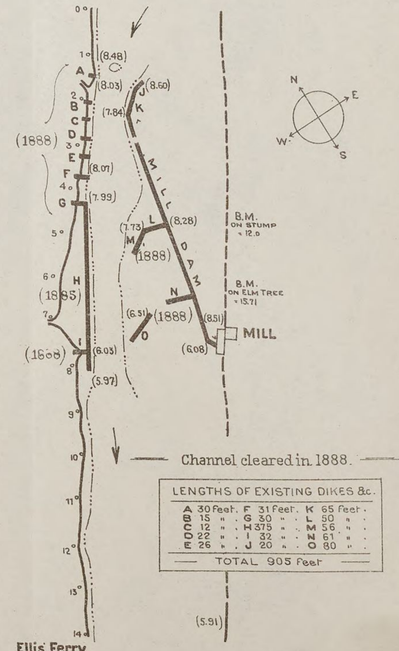
SHOAL Nº 21½

CALLED

GRIMES MILL SHOAL

31.0 MILES ABOVE W.N.C.R.R. BRIDGE

Surveyed 18 & 19 Oct. 1888,
when water stood at 0.25 Ft. above low winter water.
Least Channel Depth = 2,65 Ft. at low winter water. in 1888.
3,0 Ft. " " " " " 1890.



Channel cleared in 1888.

LENGTHS OF EXISTING DIKES &c.					
A	30 Feet.	F	31 Feet.	K	65 Feet.
B	15 "	G	30 "	L	30 "
C	12 "	H	375 "	M	56 "
D	22 "	I	32 "	N	51 "
E	26 "	J	20 "	O	80 "
TOTAL 905 Feet					

EARTH AND MILL DAMS

AND

OUTLINE MAP

OF

ADRIAN, MICH.

SHEET 8.

near Salisbury, up 33 miles. No commerce can be expected until about $10,000 more has been spent on this portion of the river; then a small boat may be placed on 33 miles of the river.

The river flows through a fertile country, mainly without railroad facilities. Were the river open to free and safe navigation all the year a commerce of from $500,000 to $1,500,000 would soon be developed, but such an improved navigation, costing about $600,000 for construction and $25,000 per year for maintenance, is not contemplated at present. The restricted flush-water navigation sought by the present project may furnish an annual commerce of $500,000 per year in a few years after the improvement is finished.

The products of the neighborhood for the year ending December 31, 1889, are estimated roughly as follows:

Articles.	Quantity.	Rate per item.	Value.
Indian corn.....bushels..	331,334	$0.60	$198,800
Wheat.....do...	150,000	.90	135,000
Rye.....do...	5,000	.80	4,000
Oats.....do...	49,500	.40	19,800
Tobacco.....pounds..	228,000	.13	29,644
Cotton.....bales..	2,100	45.00	94,500
Total.....	.....	.....	481,744

The above products were principally hauled in wagons many miles to the railroad, and they would probably have found their way to market down the river were it in a navigable condition, saving much expense to the farmers in the transportation.

The above statistics are based mainly upon the report of overseer Frank Brown. His report was made from a personal knowledge of the district.

M 14.

IMPROVEMENT OF HARBOR AT GEORGETOWN, SOUTH CAROLINA.

HISTORY OF OPERATIONS.

(1) *Reference to past reports.*—For special description of harbor, see pages 1036–1037, Annual Report for 1881; for special history of past work, see page 1029, Annual Report for 1886; for map of harbor, see page 1076, Annual Report for 1887.

(2) *Original condition.*—Georgetown is situated at the head of Winyaw Bay, and at the confluence of the Sampit, Black, Great Pee Dee, and Waccemaw rivers (these rivers having conjointly a drainage area of 18,040 square miles), and is the natural harbor and sea-port for all commerce passing to and from these rivers and their tributaries. Georgetown is also a railroad terminus.

When placed under governmental improvement, in 1880, this harbor had an excellent, well-protected anchorage of at least 1 mile in length, 150 feet width, and 15 feet depth. A bar of about 2,850 feet length and with only 9 feet depth of water was the only obstacle to an otherwise good 13 foot navigation from Georgetown 13 miles to the ocean. The commerce of this harbor is estimated to have then been about $4,000,000 of transported goods per year, carried by thirty schooners, seven steam-boats, and two steam-tugs, measuring in all about 9,000 tons.

(3) *Plan of improvement.*—The original project of 1881, as continued to date, proposed to secure a dredged channel of 200 feet bottom width and 12 feet low-water depth entirely through this bar. A personal inspection of this locality and work in 1884 showed the present and future

commercial importance of this harbor and the worthiness of the improvement.

The total final cost of this work was estimated in 1889 to be $44,500.

The aggregate amount appropriated upon this project up to June 30, 1890, is $24,500.

(4) *Results.*—Up to June 30, 1889, a total of $23,842.63 had been expended in all, giving a through cut entirely across the bar, with 12 feet low-water depth, and with a variable width of from 80 to 100 feet.

In consequence of the governmental improvements around this harbor the commerce had rapidly increased, being then about $5,500,000 of transported goods per year; showing that each dollar once spent upon this improvement had been accompanied by the development of about $89 of annual commerce.

(5) *Work of the past year.*—The special work of the past year is as follows: Expenditures, $34.94; value of United States plant $260.

Active work was stopped May 22, 1889, for want of funds.

During the past year all work has been confined to office duties and minor work, a small reserve being retained for use in case of emergencies.

Inspections of the work were made during the year.

This improvement has been under the efficient supervision of Assistant Engineer Reid Whitford, whose report is herewith appended.

The channel dug in past years is deepening as desired under the tidal scour. The commerce is steadily increasing. Otherwise the general situation is the same as at the commencement of the fiscal year. A single appropriation to complete this work is much needed.

The latest reliable commercial statistics for the year ending December 31, 1889, are herewith appended, showing an annual commerce of $7,919,700 (about 196,754 tons) worth of goods transported per year.

(6) *Recommendations for future work.*—It is recommended: That the above improvement be completed in accordance with the present approved and adopted project, so as to secure a channel of 12 feet depth at mean low water, and of about 200 feet bottom width entirely through the bar; at a total expense of $20,000 in addition to the funds available June 30, 1890; this amount to be appropriated in one sum. Smaller yearly appropriations involving the alternate disorganization and reorganization of working parties, damage to unfinished work, extra superintendence, and deterioration of plant, may increase the cost of the work by about $2,000 per appropriation.

The channel once thoroughly opened will probably be permanent. By this improvement ocean vessels of 12 feet draught, after once crossing the Winyaw Bay Bar, can proceed without further delay 15 miles further to their anchorage at Georgetown.

Georgetown is a port of entry.

Money statement.

July 1, 1889, amount available	$657.37
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	34.94
July 1, 1890, balance available	622.43
Amount appropriated by act of September 19, 1890	8,000.00
Amount available for fiscal year ending June 30, 1891	8,622.43
Amount (estimated) required for completion of existing project	12,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	12,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. REID WHITFORD, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Georgetown, S. C., June 30, 1890.

CAPTAIN: I have the honor to make the following report relative to harbor at Georgetown, S. C., for fiscal year of 1889–1890.

Owing to the want of funds, there was no work done under the present approved project of dredging through the shoal at the mouth of the Sampit River. Engineer property has been cared for and records completed.

REMARKS.

The channel so far as completed (shown in the Annual Report of Chief of Engineers for 1789, page 1102) is of great benefit to commerce, and is in daily use by the shipping of Georgetown. The depth dredged seems to remain so without much, if any, filling. When finally finished it will be what Georgetown has needed since the beginning of its existence, for report says that this shoal has always been a detriment to the commerce of the place.

RECOMMENDATIONS.

It is respectfully recommended that a detailed survey of the mouth of the river, including careful soundings in the channel heretofore dredged, be made before work is resumed under the project.

COMMERCE.

For a detailed statement of commerce and list of vessels, with which it is carried on, you are respectfully referred to papers already forwarded bearing upon this subject. In the calendar year of 1888 the commerce amounted, in the aggregate, to approximately 157,521 tons; in 1889 it was about 196,754 tons according to the best account that could be obtained, showing an increase of 39,233 tons in the 12 months. While this is not large, still it is believed that it indicates a steady and permanent development of Georgetown's commercial resources.

There has been an increased number of large sea-going sailing vessels put in the railroad cross-tie trade, which is fast becoming a business of great importance and value, In the same trade a steam-ship has made one trip to this place. Other than this there have been no new lines of transportation established, but the vessels, both steam and sailing, in and out of the harbor, have probably made some extra trips.

Two new lumber mills have been established and the capacity of the old one increased during the year. There has been completed also and put in operation a barrel factory, and a first class furniture factory is about ready to begin work.

EMPLOYÉS.

Mr. Wm. Alden James, clerk, has shown his usual zeal, energy, and accuracy in the faithful discharge of his duties and he has my thanks for the most efficient aid rendered me.

Very respectfully, your obedient servant,

REID WHITFORD,
Assistant Engineer.

Capt. W. H. BIXBY,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

When the improvement was recommended in 1881 the harbor had an excellent well-protected anchorage of at least 1 mile length, 150 feet width, and 15 feet depth, but with an entrance bar allowing only 9-foot draught boats to pass at low water. The commerce is now estimated to have then been about $4,000,000 per year, carried by seven steamers, two tugs, and thirty ocean schooners and ships. No work on the improvement was commenced until 1884 for want of funds.

At present the improvement is still incomplete. A narrow passage of at least 110 feet width and 12 feet draught has been cut through the bar. The commerce is now estimated at about $7,900,000 per year, carried by nine steamers, seven tugs, and ocean

schooners and ships (no definite nnmber could be obtained), a gain of over $3,000,000 in the past nine years.

The completion of this improvement will add considerably to the commerce of Georgetown and will lessen rates of insurance and freights. The presence of this inner bar at Georgetown Harbor, taken in connection with the outer bar at Winyaw Bay, has in the past caused a delay of at least two days to vessels entering and leaving Georgetown. The removal of the Georgetown Bar will shorten this delay to one day. In the present partially improved condition of the channel vessels leaving Georgetown can, by using care, save this day now. Georgetown is the natural harbor and seaport of 18,000 square miles of fertile lands belonging to the Sampit, Waccamaw, and Pee Dee River basins. The development of northern South Carolina requires that Georgetown Harbor be given a deeper channel and better communication to these rivers and to the ocean.

CUSTOM-HOUSE STATISTICS.

ARRIVED.

Year.	Coastwise.			Foreign ports.						Total.		
				American vessels.			Foreign vessels.					
	No.	Tons.	Crew.	No.	Tons.	Crew.	No.	Tons.	Crew.	No.	Tons.	Crew.
1888....	352	124,155	2,818	2	479	14	1	81	8	355	124,715	2,840
1889....	365	128,705	2,920	2	424	16	1	149	7	368	129,278	2,943

CLEARED.

1888....	342	121,715	2,735	8	1,835	45	1	81	8	351	123,631	2,798
1889....	357	126,965	2,856	6	1,494	55	1	149	7	364	128,608	2,908

The commerce for the year ending December 31, 1889, is estimated as follows:

Class of goods.	Exports.	Imports.	Total.
Cotton and products	$1,500,000	.....	$1,500,000
Rice	708,400	.....	708,400
Live stock and products	5,800	.....	5,800
Fish, oysters, etc	100,000	.....	100,000
Naval stores	1,328,500	.....	1,328,500
Lumber and products	512,000	.....	512,000
General merchandise	.....	$3,750,000	3,750,000
Sundries	15,000	.....	15,000
Total	4,169,700	3,750,000	7,919,700

Approximate tonnage, 196,754 tons; gain during year, 39,233 tons.

No new transportation lines established.

The above statistics are based mainly upon the reports of Assistant Engineer Reid Whitford, made after much correspondence and conversation with steam-boat captains and agents, custom-house officials, and prominent shippers and merchants.

The commerce at present as above shown is (196,754 tons)	$7,919,700
The commerce before the improvement began was	4,000,000
The development of commerce since beginning of improvement is	3,919,700
Expended on improvement up to December 31, 1889	23,883
The development of annual commerce for every dollar spent on the improvement since its commencement is	170

M 15.

IMPROVEMENT OF WINYAW BAY, SOUTH CAROLINA.

HISTORY OF OPERATIONS.

(1) *Reference to past reports.*—For special description and maps of bay, see pages 1154–1170, Annual Report for 1885, page 1114, Annual Report for 1889.

(2) *Original condition.*—Winyaw Bay is the natural and only ocean entrance to Georgetown Harbor and to the Sampit, Black, Great Pee Dee, Waccemaw rivers and their tributaries, with their 500 miles of navigable river, 18,000 square miles of drainage area, and their large combined annual commerce.

When placed under Governmental improvement in 1886 this bay possessed only 9 feet depth at low water and 12 feet at high water on its bar entrance, and 12 feet depth from the bar for 12 miles up to Georgetown. The commerce of the bay is estimated to have then been about $5,500,000 of transported goods per year.

(3) *Plan of improvement.*—The original estimates of 1885, as continued to date, proposed to secure a permanent bar entrance of 12 to 20 feet depth at low water. When the existing Santee (Mosquito Creek), Congaree, and Wateree river improvements are completed Winyaw Bay will become the entrance to the river basins of one-sixth of North Carolina and one-third of South Carolina, with about 900 miles of navigable river, 34,000 square miles of drainage area, and $12,000,000 of annual commerce. The volume of water moving through the throat of this bay at mid ebb daily, at an average velocity of 2.1 feet per second, is sufficient to actually maintain at this point a channel of 4,000 feet width and 21 feet average depth, so that by the proper expenditure of money there should be no difficulty in obtaining a good bar entrance with 15 to 20 feet depth at low water.

The total final cost of this work was estimated in 1885 to be $2,500,000 for a bar depth of from 15 to 20 feet, the funds to be voted in amounts of about $300,000 per year, the first $800,000 being estimated to give 12 feet depth.

The aggregate amount appropriated for this project up to June 30, 1890, is $118,750.

(4) *Results.*—Up to June 30, 1889, a total of $6,980.26 had been spent in all upon this improvement in making necessary preparations for beginning work.

The commerce was then about $7,000,000 of exports and imports per year, the development of the last few years having been due to the Governmental improvement of the tributary rivers.

(5) *Work of the past year.*—The special work of the past year is as follows: Expenditures, $13,047.19; value of United States plant, $600.

One steam-launch and other United States plant was in use during the year.

Owing to the difficulty of properly specifying it beforehand and measuring it afterwards, all minor work was, for advantage and economy, allowably done by hired labor and the purchase of materials in open market.

Specifications having been prepared, bids for possible work were

solicited in June, 1890, and sealed proposals were opened July 24, 1889.

The contract was awarded to Mr. J. S. Howell of New York City, the lowest biddder.

The contract provided that work should be begun by November 1, 1889, and finished in twelve months from that date.

Preparatory to the beginning of the work all necessary surveys were made, ranges established, and the main jetty and wings located.

Work was not actually begun until February 4, 1890.

The contractor claimed that he had done all in his power to begin work by November 1, but that by the failure of other parties to complete part of his plant, and for other reasons, he was unavoidably delayed.

Since February 4, 1890, work has been progressing very slowly. Sheet-piling has been driven along the axis of the two wings and along the axis of the main jetty to low-water line, in all 105,355.87 feet B. M.; and 1,016.69 tons of stone have been put in place, as follows:

On the east wing, 304.85 tons; on the west wing, 162.64 tons; on the main jetty, 549.20 tons.

No mattress work has yet been done.

A new engine was put in the steam-launch *Oklahoma*.

Water-gauge records have been kept during a portion of the year.

The work of the United States on this improvement has been very efficiently carried on under the immediate supervision of Assistant Engineer Ried Whitford, whose report is herewith appended.

The work of the past year has not progressed sufficiently far to effect any improvement in the navigation facilities. There is only about 7 feet at low water on the ocean bar, and vessels are frequently subjected to considerable delay.

The latest reliable commercial statistics, those for the year ending December 31, 1889, are herewith appended, showing a commerce of $7,919,700 per year, about 196,754 tons.

(6) *Recommendations for future work.*—It is recommended that this improvement be carried on in accord with the existing projects by the construction of stone dikes across the sloughs and along the inner edges of the breaker shoals until a good channel of from 12 to 20 feet depth at low water is obtained at one or both bar entrances, at a total cost of from $800,000 for a 12-feet depth up to perhaps as much as $2,500,000 for a 15 to 20 feet depth; this amount to be appropriated in annual installments of as much as $300,000 each.

Various personal examinations of the locality and its surroundings have shown worthiness of this improvement (that of the outlet to the river basins of two-thirds of South Carolina) and the urgent need for large appropriations and rapid work. The first $800,000 of work will probably increase the depth on the bar to 12 feet at low water, a depth sufficient to very greatly increase and benefit the commerce of the neighboring Waccamaw, Pee Dee, Black, and Sampit rivers and Georgetown Harbor. Smaller yearly appropriations will involve the alternate disorganization and reorganization of working parties, damage to unfinished work, deterioration of plant, extra superintendence, care of plant, etc., and may increase the final cost by from $2,000 to $20,000 per year.

The improvement once thoroughly finished should remain comparatively permanent.

Money statement.

July 1, 1889, amount available		$111,769.74
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$11,449.17	
July 1, 1890, outstanding liabilities	1,598.02	
July 1, 1890, amount covered by uncompleted contracts made during the fiscal year ending June 30, 1890	72,320.59	
		85,367.78
July 1, 1890, balance available		26,401.96
Amount appropriated by act of September 19, 1890		100,000.00
Amount available for fiscal year ending June 30, 1891		126,401.96
Amount (estimated) required for completion of existing project		2,281,250.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		300,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

Abstract of proposals for diking, etc., at Winyaw Bay, South Carolina, opened at 10 o'clock a. m., July 24, 1889, by Capt. W. H. Bixby, Corps of Engineers, U. S. Army, Wilmington, N. C.

Items.	Quantities.	No. 1. John Shehan, New Rochelle, N. Y.		No. 2. Colin McK. Grant, Charleston, S. C.	
		Bid.	Amount.	Bid.	Amount.
Sheet-piling in place—					
On shore, etc	120,000 feet, B. M	$45.00	$5,400	$32.20	$3,864
Seaward, etc	360,000 feet, B. M	40.00	14,400	36.20	13,037
Oyster-shell in place—					
On shore, etc	500 cubic yards	2.50	1,250	1.35	675
Seaward, etc	1,500 cubic yards	2.00	3,000	1.29	1,935
Small stone in place—					
On shore, etc	1,000 tons	3.50	3,500	3.34	3,340
Seaward, etc	15,000 tons	3.00	45,000	3.22	48,300
Large stone in place—					
On shore, etc	2,000 tons	3.50	7,000	6.15	12,300
Seaward, etc	3,000 tons	3.00	9,000	5.95	17,850
Mattresses in place in the work	25,000 square yards	6.00	150,000	.85	21,250
Total			238,550		122,546
		Begin work within 30 days after notification of approval of contract. Work at rate of $10,000 per month.		Begin work within 1 month after notification of approval of contract. Work at rate of $8,000 per month.	

Abstract of proposals for diking, etc., at Winyaw Bay, South Carolina, etc.—Continued.

Items.	Quantities.	No. 3. William H. Morton, New York, N. Y.		No. 4. J. S. Howell, New York, N. Y.	
		Bid.	Amount.	Bid.	Amount.
Sheet-piling in place—					
On shore, etc	120,000 feet, B. M	$30.00	$3,600	$45.50	$5,460.00
Seaward, etc	360,000 feet, B. M	32.00	11,520	45.50	16,380.00
Oyster-shell in place—					
On shore, etc	500 cubic yards	2.50	1,250	.67½	337.50
Seaward, etc	1,500 cubic yards	2.50	3,750	.62½	937.50
Small stone in place—					
On shore, etc	1,000 tons	2.50	2,500	2.74	2,740.00
Seaward, etc	15,000 tons	2.50	37,500	2.74	41,100.00
Large stone in place—					
On shore, etc	2,000 tons	2.50	5,000	3.07	6,140.00
Seaward, etc	3,000 tons	2.50	7,500	3.07	9,210.00
Mattresses in place in the work	25,000 square yards	1.49	37,250	.57	14,250.00
Total			109,870		96,555,00
		Begin work within 49 days after notification of approval of contract. Work at rate of $10,000 per month.		Begin work October 1, 1889, and complete October 1, 1890.	

Items.	Quantities.	No. 5. William T. Gaynor, Fayetteville, N. Y.		No. 6. Roderick G. Ross, Wilmington, N. C.		No. 7. Southern Construction and Quarry Company, Nashville, Tenn.	
		Bid.	Amount.	Bid.	Amount.	Bid.	Amount.
Sheet-piling in place—							
On shore, etc	120,000 feet, B. M	$40.00	$4,800	$35.00	$4,200	$65.10	$7,812
Seaward, etc	360,000 feet, B. M	70.00	25,200	55.00	19,800	62.40	22,464
Oyster-shell in place—							
On shore, etc	500 cubic yards	1.35	675	1.47	735	1.50	750
Seaward, etc	1,500 cubic yards	1.43	2,145	1.57	2,355	1.45	2,175
Small stone in place—							
On shore, etc	1,000 tons	3.10	3,100	2.77	2,770	2.47	2,470
Seaward, etc	15,000 tons	2.45	36,750	2.57	38,550	2.49	37,350
Large stone in place—							
On shore, etc	2,000 tons	3.95	7,900	3.50	7,000	3.40	6,800
Seaward, etc	3,000 tons	3.10	9,300	3.25	9,750	3.45	10,350
Mattresses in place in the work	25,000 square yards	.98	24,500	.95	23,750	1.00	25,000
Total			114,370		108,910		115,171
		Begin work within 60 days after notification of approval of contract. Work at rate of $15,000 per month.		Begin work within 90 days after notification of approval of contract. Work at rate of $10,000 per month.		Begin work within 30 days after notification of approval of contract. Work at rate of $7,500 per month.	

NOTE.—There is available for the work of supervising Winyaw Bay, South Carolina, the sum of $111,000.

Recommended that contract be awarded to J. S. Howell.

PROGRESS MAP FOR 1890

WINYAW BAY, S.C.

FROM 1. JULY 1889 TO 30. JUNE 1890.

NORTH ISLAND MAIN JETTY

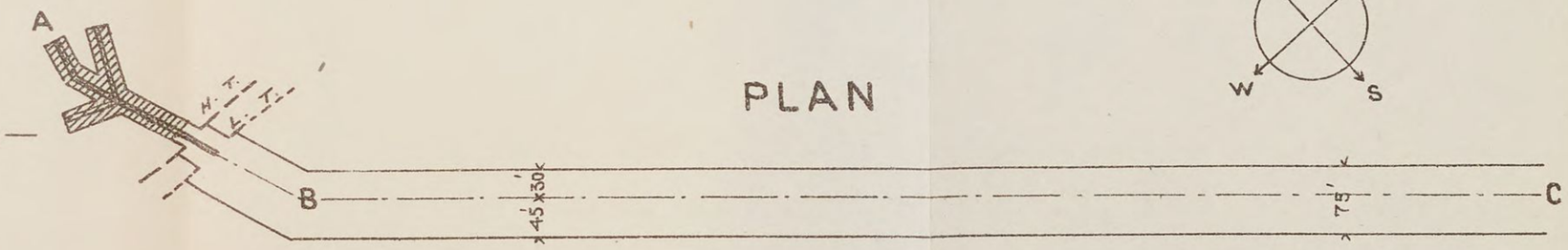
— Based on surveys of R. Whitford - 1889. —

WORK OF PREVIOUS YEARS

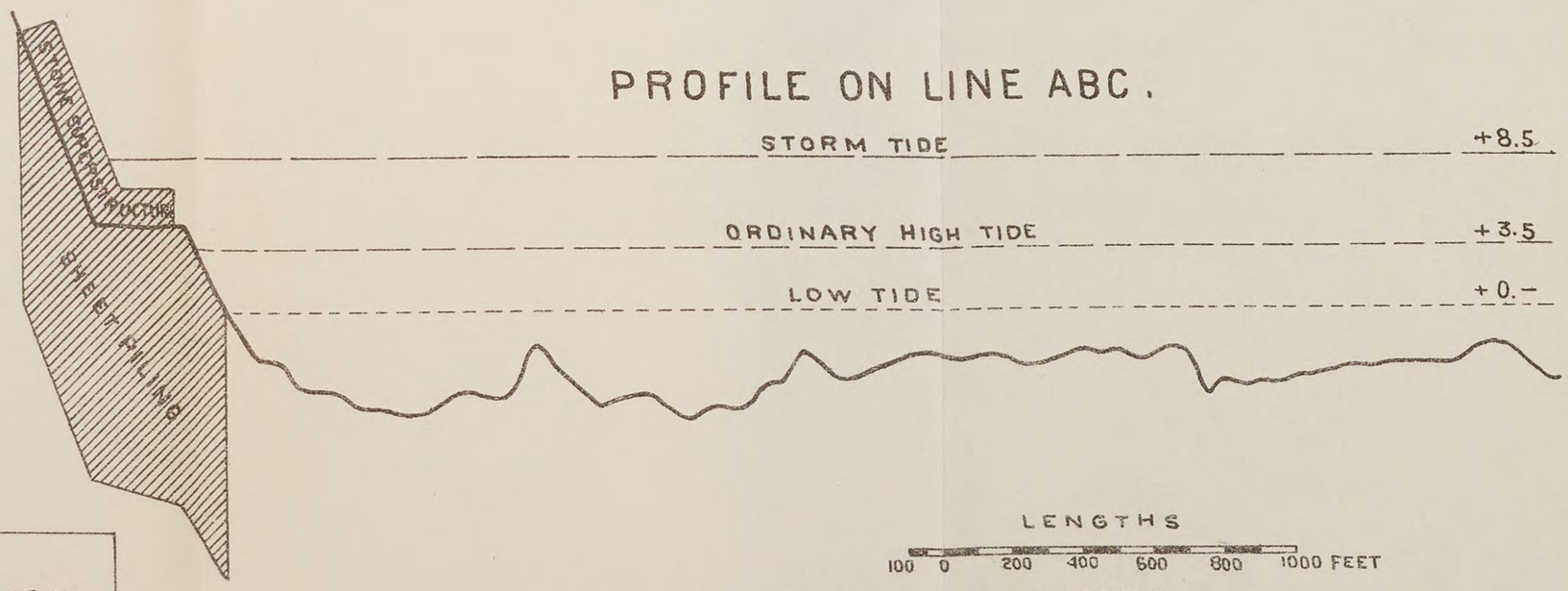
WORK OF FISCAL YEAR 1889/90.

Surveys made under direction of
Captain W.H. Bixby, U.S. Engrs.

PLAN



PROFILE ON LINE ABC.



Scales:

LENGTHS
100 0 200 400 600 800 1000 FEET

WIDTHS
100 0 100 200 300 FEET

DEPTHS
10 8 6 4 2 0 10 FEET

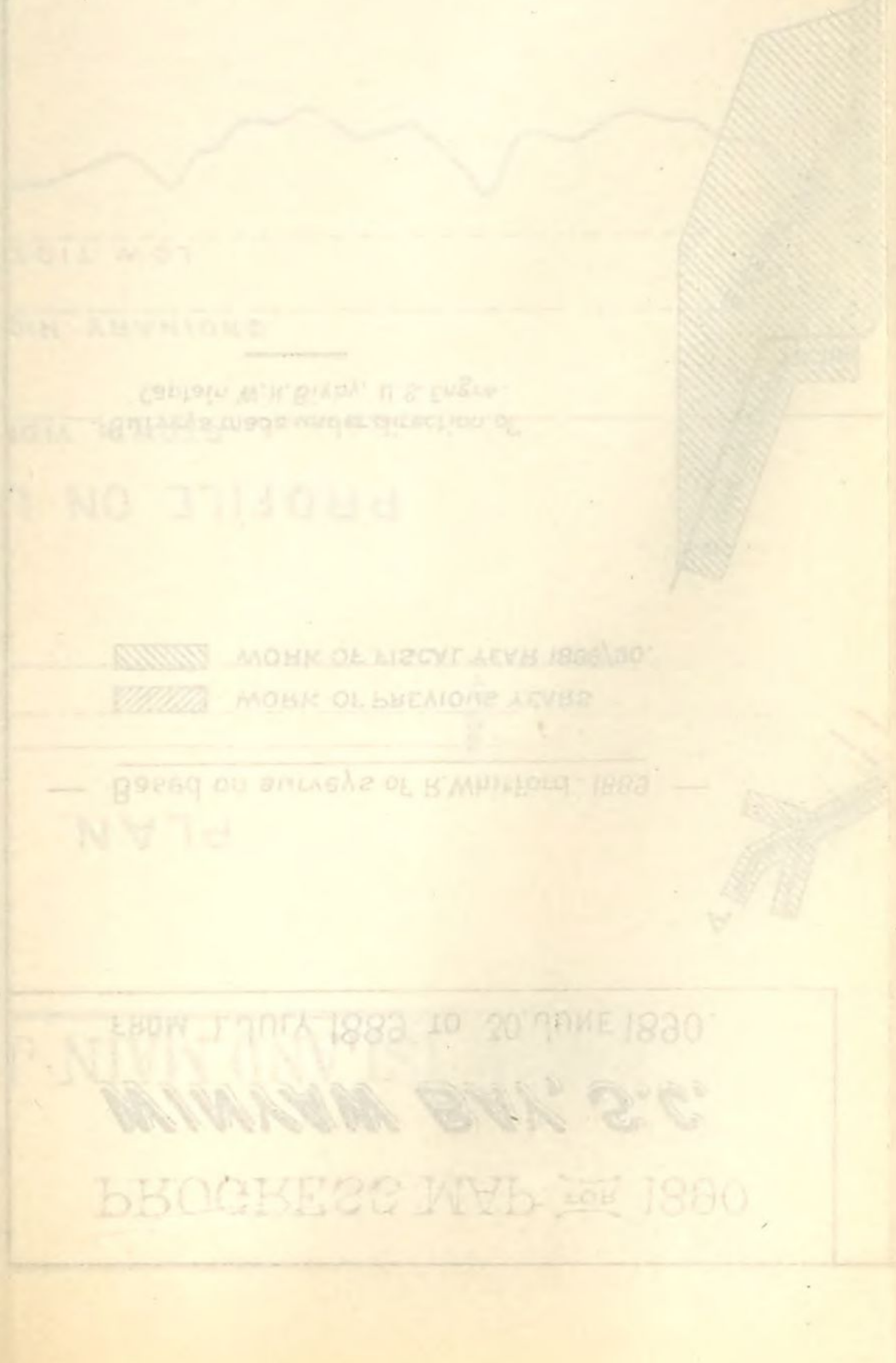
DRAWN BY P. BROSIG.

Wilmington N.C. *July 1890*

Respectfully submitted

W. H. C. Bixby

CAPTAIN OF ENGINEERS



REPORT OF MR. REID WHITFORD, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Georgetown, S. C., June 30, 1890.

CAPTAIN: I have the honor to make the following report of operations upon Winyaw Bay, South Carolina, for the fiscal year ending June 30, 1890.

STATEMENT OF WORK DONE.

Surveys.—During August and September last the lines of the North Jetty with its wings, and the east and west spur dikes, were staked off at North Island Point. The North Jetty was cross-sectioned on each side of its axis every 500 feet seawards to the end of the second section. A map showing the result of all this has been forwarded to you.

Hired labor work.—The sand along the North Jetty from near the high water to a point about 400 linear feet distant in the sand-hills; also, the total length of the east and west wings, aggregating about 343.15 linear feet (the east wing 227.15 linear feet and the west wing 116 linear feet), was excavated to an approximate depth of 3 feet below the general level of the beach, and to about 19 feet width, so as to prepare these lines for the sheet-piling to be driven, and for the foundation course of stone ballast. The excavation was done in September, 1889, February and March, 1890. A total of 4,260 yards was removed.

CONTRACT WORK.

Mr. D. V. Howell, who manages affairs here for Mr. J. S. Howell, the contractor, notified this office that he would begin operations October 1, 1889, but on account of failure to get his plant and material ready and delivered he did not do so on time. Work was finally begun by the contractor on the west wing of the land end of the North Jetty at North Island, February 4, 1890.

Sheet-piling.—It is of sound pine wood 6 inches thick, 8 to 15 inches wide, 15 to 20 feet long, and has been placed along the axis of the North Jetty from its head in the sand-hills to the low-water line, 561.8 linear feet distant; on the axis of the east wing 227.15 linear feet long, and also on the west wing 116 linear feet long. The pieces were driven so as to touch each other against their 6-inch faces over the whole of their length, and where spaces occurred laps 3 inches by 9 inches by 15 feet were used to cover them. The tops of the piles were left on a general level of the natural beach surface. All above the high-water line are 20 feet long, and all below 15 feet long.

A total of 105,357.87 feet B. M. has been driven to date; of this 25,928 feet B. M. is in the east wing, 13,424 feet B. M. in the west wing, and 66,005.87 feet B. M. in main North Jetty.

Stone-work.—1,016.69 tons (of 2,000 pounds) of small stone or ballast have been distributed along the entire lines of the east and west wings, and on the North Jetty reaching from its head to a point 405 linear feet distant. The stone is placed along each side of the sheet-piling on the sand bottom of the excavated pits so as to cover 8.5 feet in width on the sea or exposed side, and 4.5 feet in width on the other side of the sheet-piling. The stone thus placed has a general thickness of about 2 feet, and was packed as solidly and as level as possible.

Of the 1,016.69 tons, 304.85 tons were used on the east wing, 162.64 tons on west wing, and 549.20 tons on main jetty.

Mattress work.—None.

Special work.—By agreement, Mr. Thomas W. Daggett constructed a house at North Island for office and quarters, beginning it in May last and finishing it in this month.

GENERAL REMARKS.

All work so far completed has been well and substantially executed by the contractor.

The depth on the outer bar still remains shallow, about 7 feet at low tide and 11.5 feet at high tide, to the great inconvenience, delay, and detriment of the commerce of Georgetown and its neighboring rivers and towns.

COMMERCE.

For a statement of this in detail and list of vessels by which it is carried on, you are respectfully referred to papers bearing upon the subject already forwarded.

In the calendar year of 1888 the commerce amounted to approximately 157,521 tons; in 1889 it was about 196,754 tons according to the best account that could be obtained, showing an increase of 39,233 tons in the twelve months. While this is not strikingly large, still it is believed that it indicates a steady and permanent devel-

opment of Winyaw Bay's commercial resources, and shows the necessity for deeper water at the entrance to the bay. There has been an increased number of large, sea-going sailing vessels put in the railroad cross-tie trade, which is fast becoming a business of great importance and value. In the same trade a steam-ship made one trip here from the North. Other than the above there have been established no new transportation lines, but the vessels, both steam and sailing, have probably made some extra trips.

Two new lumber and shingle mills, a furniture factory, and a barrel factory have been started, and the capacity of the existing lumber and shingle mills increased.

EMPLOYÉS.

Much credit is due Messrs. LeGrand G. Walker and William T. McNelty, inspectors, as well as Mr. S. F. Burbank, subinspector, for the faithful and efficient performance of their duties.

Very respectfully, your obedient servant,

REID WHITFORD,
Assistant Engineer.

Capt. W. H. BIXBY,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

This bay is the ocean entrance to Georgetown Harbor, South Carolina.

The present commerce of this bay is that of the Waccamaw, Pee Dee, Black, and Sampit rivers and Georgetown Harbor, a commerce carried by ocean vessels (no definite number could be obtained) and two steamers making semi-weekly trips to Charleston. At the ocean bar there is at present only 7 feet depth at ordinary low water; otherwise navigation is practicable for boats of 12 feet draught. At present, however, vessels drawing no more than 10 to 12 feet are frequently detained for several days and sometimes weeks awaiting a flush high water to take them over the bar; and however great the distress in which a vessel may be while approaching the harbor, no tug drawing over 6 to 7 feet can go to her assistance during low water.

Already Winyaw Bay is the outlet to about $8,000,000 of annual commerce of the Sampit, Black, Pee Dee, and Waccamaw rivers. More than this, it is now connected by a 7-mile canal to the Santee River, so that it will soon be the shortest and most accessible outlet to $5,000,000 of annual commerce, which will come down the Congaree, Wateree, and Santee rivers as soon as the railroad bridges over these rivers are properly furnished with draw-spans. These river basins at present raise over 400,000 bales ($16,000,000) of cotton per year (see 1880 Census Reports). These rivers are now navigable over 800 miles by steamers and over 1,000 miles by pole-boats. The amount of water now flowing in and out of Winyaw Bay at mid-tide is about 220,000 cubic feet per minute, sufficient to keep open passage of 4,000 feet width and 21 feet average depth if provided with proper training-walls or dikes. All opinions of the Government engineers in charge of this improvement, so far, have been to the effect that the bar is well worthy of improvement, and that it can be easily improved provided the necessary funds are voted in adequately large annual appropriations. An immediate appropriation of $300,000, properly spent, would undoubtedly develop at once an additional commerce of $8,000,000 per year.

The Georgetown and Western Railroad Company, in March, 1888, put on a regular line of first-class steam-ships between New York and this place, to run in connection with that road, but were obliged to take it off in 1889 on account of the bad condition of the ocean bar.

Full statistics as to the commerce have been sought unsuccessfully; but those attainable give approximate estimates as follows:

The commerce for the year ending December 31, 1889, is estimated as follows:

The commerce for the year ending December 31, 1889, is estimated as follows:

Class of goods.	Exports.	Imports.	Total.
Cotton and products	$1,500,000	.....	$1,500,000
Rice	708,400	.....	708,400
Live stock and products	5,800	.....	5,800
Fish, oysters, etc	100,000	.....	100,000
Naval stores	1,328,500	.....	1,328,500
Lumber and products	512,000	.....	512 000
General merchandise	.....	$3,750,000	3,750,000
Sundries	15,000	.....	15,000
Total	4,169,700	3,750,000	7,919,700

Approximate tonnage, 196,754 tons; gain during year, 39,233 tons.
No new transportation lines established during year.
The above statistics are based mainly upon the reports of Assistant Engineer Reid Whitford, made after much correspondence and conversation with steam-boat captains and agents, custom-house officials, and prominent shippers and merchants.

The commerce at present, as above shown, is (196,754 tons)	$7,919,700
The commerce before the improvement began was	4,000,000
The development of commerce since beginning of improvement is	3,919,700
Expended and pledged on improvement up to December 31, 1889	89,858
The development of annual commerce for every dollar spent on the improvement is	44

M 16.

PRELIMINARY EXAMINATION OF THE ROANOKE RIVER, VIRGINIA, BETWEEN CLARKSVILLE AND EATON FALLS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., December 16, 1889.

SIR: I have the honor to submit herewith a copy of the report dated December 10, 1889, upon the preliminary examination of the Roanoke River between Clarksville and Eaton Falls, Virginia, made by Capt. W. H. Bixby, Corps of Engineers, to comply with the requirements of the river and harbor act of August 11, 1888, and accompanying map.

It appears from the report of Captain Bixby that the slope of the river from Clarksville to Eaton Falls is 2.6 feet per mile, and its navigation is obstructed by projecting ledges and points of rock, and steep slopes at the various falls. These obstructions, while not preventing a small existing pole-boat navigation, are serious hindrances to any steam-boat navigation, even by boats of from 30 to 40 tons burden.

The present actual commerce of the river is limited to two or three pole-boats, carrying about 1,000 bales of cotton down-stream, and about 400 tons of fertilizers up-stream, making trips two or three times a week during six months of the year, and constituting a commerce valued at about $64,000 over the lower quarter of the river between Robinson's Ferry and South Gaston.

Captain Bixby is of opinion that it is very doubtful, even with the river and channel improved at the estimated cost of $280,000, whether any large commerce would be thereby developed for many years, and, considering the circumstances, expresses the opinion that the "Roanoke River, from Clarksville, Va., to Eaton Falls, North Carolina, is to-day not worthy of improvement by the General Government."

His views are concurred in by me.

Very respectfully, your obedient servant,

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

Hon. REDFIELD PROCTOR,
Secretary of War.

REPORT OF CAPT. W. H. BIXBY, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Wilmington, N. C., December 10, 1889.

GENERAL: I have the honor to submit herewith the following report upon the examination of the Roanoke River, Virginia, between Clarksville and Eaton Falls, ordered by river and harbor act of 11th August, 1888, and assigned to me by letters from your office dated 28th August and 29th September, 1888.

This portion of the Roanoke River has been the subject of several examinations and surveys, both by the State of North Carolina and the United States. In accordance with the river and harbor appropriation bill of 1881, and under direction of United States Civil Engineer S. T. Abert, Mr. W. W. Anderson made a careful survey of the Roanoke River from Clarksville, Va., down past Eaton Falls to Weldon, N. C., and the report of this survey may be found in pages 1060 to 1066, Annual Report, Chief of Engineers for 1882. In accordance with the river and harbor appropriation bill of 1886, and again under direction of United States Civil Engineer S. T. Abert, a report was also made upon the portion of river from Clarksville to Eaton Falls. In neither case did the United States engineer specially recommend this part of the river as worthy of improvement, but he estimated that $182,000 in three annual appropriations would probably give a channel of 35 feet width and 2½ feet depth at low water from Clarksville to Eaton Falls, and that a very great further expense (not warranted by the then demands of commerce) would have to be incurred in the reconstruction of an old abandoned system of canal and locks for a distance of 12 miles to extend the navigation from Eaton Falls to Weldon, the present head of steam navigation in the Roanoke.

The following report is based upon information obtained either by letter or word of mouth from various persons living upon this river or interested in its navigation, as well as upon the reports and maps of Mr. Abert and Mr. Anderson; all being checked and assisted by my own general knowledge of the neighborhood and by my own personal inspection of the river from Clarksville to Eaton Falls by pole-boat at the lowest water of 1889, former maps being kept in hand during the trip.

The Roanoke River is formed by the Dan and Staunton rivers, which meet at Clarksville, bringing down an estimated low-water flow of about 1,400 cubic feet per second from a total drainage area of about 7,100 square miles. From Clarksville the Roanoke flows in a general south-by-easterly direction through Mecklenburgh County, Va., Warren County, N. C., and thence between Northampton and Bertie counties on the north and Halifax and Martin counties on the south, a distance of 56 miles by river (47 miles by air line), to Eaton Falls; thence 13 miles by river (11 miles by air line) to Weldon; and thence 129 miles by river (60 miles by air line) to its mouth in Albemarle Sound. From Clarksville to Eaton Falls the river falls 146 feet (2.6 feet per mile); from Eaton Falls to Weldon, 104 feet (8 feet per mile); but below Weldon it has so gentle a slope (about 0.3 foot per mile) and so good a channel that it is there easily navigable by steamers of 3 feet draught all the year, and of 5 feet draught during the greater part of the year. From Clarksville to Eaton Falls the river flows most of the way over a granite rock bed, and between banks of from 12 to 120 feet height, having a general depth of 2½ feet at low water (varying from 1 to 10 feet at places) and a width of from 500 to 1,300-feet; the river valley bottom having a width of from 1,000 to 15,000 feet. In freshet the river overflows its banks in many places, the water rising to from 12

to 15 feet under ordinary circumstances and to from 20 to 50 feet in special cases perhaps once or twice per year. A freshet of 20 feet height at Clarksville causes about 30 feet height at points 30 to 40 miles lower down the river, about 18 feet at Eaton Falls, and about 40 feet at Weldon. The soil of the river valley bottom is very rich and exceedingly productive in years free from overflow by high freshets, and the uplands are also of excellent quality, both together producing good crops of cotton, tobacco, corn, wheat, etc. About 300,000 acres of land lie within 5 miles of this part of the river, of which perhaps 100,000 acres, already cleared, are capable of producing about $3,000,000 of crops if well furnished with labor and transportation facilities (both of which, however, are at present poor). No creeks or streams of any size enter the river, and no bridges cross it, between Clarksville and Eaton Falls.

Clarksville, Va., is a small town of about 800 population, formerly the seat of large tobacco trade, but now mainly important as the point where two lines of railroad cross the head of the Roanoke River. It will undoubtedly soon begin to acquire some commercial importance as a railroad center and as the shipping point of products coming from the lower Dan and Staunton River valleys; but at present its commerce is hardly enough to support its present population. Between Clarksville and Eaton Falls there are a few post-offices, but no settlements of any size, on or near the river bank. At Eaton Falls there is the post-office and railroad station of Gaston, a place, however, of almost no commerce and of only about 50 population.

The main obstructions to navigation at present are shallow general depths, projecting ledges, and points of rocks, and steep slopes at the various falls or so-called shoals of the river. These obstructions, while not preventing a small existing pole-boat navigation, are yet serious obstructions to any steam navigation even by small boats of from 30 to 40 tons burden. The following table shows the general distribution of these obstructions in this portion of the river and the cost of their improvement so as to leave a channel-way for small steam-boats of about 20 feet width and 2 feet draught, if furnished with means of hauling themselves up at the shoals through short sluices where the grade may be as much as 10 feet per mile for a short distance at dead low-water stages.

Locality.	Distance below Clarksville.	Fall from Clarksville.	Fall during interval to be improved.			Estimated cost of improvement.*
			Total.	Distance.	Average per mile.	
	Miles.	*Feet.*	*Feet.*	*Miles.*	*Feet.*	
Fair River	4.0	10.2	10.2	4.0	2.5	$4,000
Blue Hell and Jonnson's Sluice	4.7	19.0	8.8	0.7	12.6	25,000
Do	9.9	37.0	18.0	5.2	3.5	2,000
Butcher's Creek and Eagle Point	10.5	44.0	7.0	0.6	11.7	20,000
Do	21.9	69.8	25.8	11.4	2.3	†7,000
Bugg's Island	22.1	72.1	2.3	0.2	11.5	5,000
Do	22.6	73.1	1.0	0.5	2.0	800
Short Falls	23.0	75.7	2.6	0.4	6.5	5,000
Do	34.0	86.0	10.3	11.0	0.9	5,000
Boyd's Mill Shoals	35.0	94.0	8.0	1.0	8.0	25,000
Do	48.6	109.0	15.0	13.6	1.1	‡7,000
Lizard Creek Shoals	49.1	115.3	6.3	0.5	12.6	15,000
Do	49.7	115.6	0.3	0.6	0.5	500
Pugh Shoals	49.9	120.0	4.4	0.2	17.0	§35,000
Do	51.4	123.8	3.8	1.5	2.5	1,000
Sturgeon's to Allen's	53.8	144.4	20.6	2.4	8.6	70,000
Fair River	56.1	146.2	1.8	2.3	0.8	700
Superintendence and contingencies, 23 per cent	.....	.....	.....	.....	.....	228,000 52,000
						280,000

* For steam-boats of 20 feet width and 2 feet draught, leaving a maximum grade of 10 feet per mile.

† Includes rock excavation at King's Ford.

‡ Includes rock excavation at Collar Bone Falls.

§ Specially expensive because of mid-river channel.

Fuller details of the various shoals and falls of the river, and the relative cost of the improvement of each, may be found in the reports of Mr. Abert and Mr. Anderson (pages 1061 to 1066 of Annual Report Chief of Engineers for 1882). The maps* of Mr. Anderson's surveys, showing the river in plan and its water surface and its bed in profile, are herewith inclosed, these maps having been corrected up to 1889. Actual recent experience in the improvement of neighboring similar rivers, the Dan, Staunton, New, Yadkin, and Upper Savannah, has shown that Mr. Anderson's estimates of 1882 for the Roanoke should be increased nearly 100 per cent. in order to insure the desired results, and the present estimates (shown in the above table) are based upon this recent experience.

The value of this river improvement must depend greatly upon its relation to other transportation routes in its neighborhood or upon its superior advantages for transportation of the materials brought within its reach. Below the head of Eaton Falls, and from there to Weldon, the fall of this river, 104 feet in 13 miles (8 feet per mile), is so placed that no navigation can ever be safe except by the aid of dams, canals, and locks, whose cost may be roughly estimated at about $900,000 for pole-boats and small steam-boats of about 20 feet width and 3 feet draught. As there is no commerce at present warranting any such expenditure, and no prospect of any such commerce for many years, the river above Eaton Falls must be considered as having no water communication with the river below Weldon, and as dependent for its commerce entirely upon its railroad outlets and connections at Clarksville and Eaton Falls. Under such circumstances the improvement of this river loses much of the commercial value which might otherwise be expected from a river of its size and flow, since it thus has almost no control upon freights, and offers almost no special advantages for the transportation of either heavy or light materials. This river basin is one of great water-power and of great agricultural wealth, but at the same time one which is at present far better adapted to a development by the construction of railroads up its valley rather than by the improvement of its water-ways.

The navigation of this river was, from 1812 to 1875, controlled by the Roanoke Navigation Company, which in about 1824 had so improved the channel by sluices and low training-walls as to allow the descent of pole-boats from the Dan and Staunton to Eaton Falls, and thence by canals and locks to Weldon. In the prosperous days of this company as many as 355 pole-boats were in use on the river, carrying perhaps $6,000,000 of annual commerce. In those days, however, there were no railroads across the Dan and Staunton basins, while there was a railroad direct from Eaton Falls (North Gaston railroad station) to Petersburg, Norfolk, and other Virginia ports. To-day all the products of the Dan and Staunton are more economically and quickly carried off by the Richmond and Danville and the Norfolk and Western railroads, and by the four railroad routes leading from Clarksville to Oxford and Danville, N. C., and to Keysville and Norfolk, Va., so that nothing but the local products of 50 miles of river basin above Eaton Falls now remain to be carried off by the river boats and the present railroad from Eaton Falls (now South Gaston railroad station) westward to Raleigh, and eastward to Weldon and Norfolk.

The present actual commerce of the river is limited to two or three pole-boats, which make trips two or three times per week during about six

*Omitted; printed in House Ex. Doc. No. 62, Fifty-first Congress, first session.

months of the year when transportation is most needed, carrying about 1,000 bales of cotton down-stream and about 400 tons of fertilizers and general merchandise up-stream (about $64,000 total commerce over the lower quarter of the river between South Gaston and Robinson's Ferry. The river is even now in such condition that these same pole-boats might easily at present make a round trip from South Gaston to Clarksville and return weekly during nine months of the year (all the busy transportation season, if there were enough demand for such means of transportation along this section of river valley. Steam-boats, however, would not make much use of this route unless it were very extensively improved, for several reasons: First, the river being here subject to frequent and heavy freshets (which overflow its banks, carry much drift, rise to heights as previously stated, and cause excessive velocities at shoals and falls), no ordinary system of locks and dams would secure the safe passage of boats at all times of the year; second, the river-bed is almost everywhere of rock and full of rough, ragged, projecting points or ledges, especially at the places where the slopes are steepest and the current consequently swiftest, so that the channel would have to be much deeper than the draught of the boat and several times wider than the elear width of the boat, or else the latter would be in constant danger of being wrecked, and would therefore have to charge excessively high freights to cover its proper insurance or repair. Even were the river channel improved to the extent indicated in the above table, and at the there estimated cost of $280,000, it is, in my opinion, very doubtful whether any large commerce would be thereby developed upon this stream for many years, and the cost of the improvement of this river for steam-boat navigation therefore appears to me altogether too great in comparison with the advantages to be derived therefrom until a day when the mineral resources and manufacturing interests of the valley shall be far more fully developed than at present.

Under the above circumstances, I am therefore of the opinion that the Roanoke River from Clarksville, Va., to Eaton Falls, North Carolina, is to-day not worthy of improvement by the General Government.

Very respectfully, your obedient servant,

W. H. BIXBY,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

M 17.

PRELIMINARY EXAMINATION AND SURVEY OF FISHING CREEK, NORTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
Wilmington, N. C., November 23, 1889.

GENERAL: I have the honor to submit herewith the following report upon the examination and survey of Fishing Creek, North Carolina, ordered by river and harbor act of August 11, 1888, and assigned to me by letters from your office dated August 28 and September 29, 1888.

The following report is based upon information obtained either by letter or word of mouth from various persons living upon this river or interested in its navigation, as checked and assisted by my own general knowledge of the neighborhood and by my own detailed boat inspec-

tion and rough maps of the 38 miles of river between its mouth and Bellamy's Mill, just above the Wilmington and Weldon Railroad Bridge near Enfield, N. C.

Fishing Creek is a stream of about 120 miles total length (about 50 in an air line) and of about 760 square miles of drainage area. It rises in Warren County, flows in a general southeasterly direction, forming for some distance the boundary line between Warren and Halifax Counties on the north, and Franklin, Nash, and Edgecombe Counties on the south, and empties into the Tar River about 8 miles above Tarborough. The average rain-fall in this area is reported at about 47 inches, distributed with tolerable uniformity throughout the entire season. At Bellamy's Mill, near Enfield (38 miles above its mouth), this stream is barred against an upward navigation by a mill-dam of 160 feet length and 12 feet height, over whose sill the water is reported to run with an average depth of 12 inches for the entire year. Below Bellamy's Mill this stream has a depth of about 4 feet at ordinary stages, flows between high banks, has a gentle slope, and is suitable for navigation by small stern-wheel 30-ton to 50-ton steam-boats, such as are now in use on similar streams in other parts of the State.

This stream between Bellamy's Mill and its mouth is crossed by nine county bridges and one railroad bridge, all without draws at present.

The general features of the lower part of this stream are shown in more detail in the following table, based upon my own personal examination and maps:

Distances.		Locality.	Observed.										
			Water-way.			Curvature.		Banks.					
Miles from mouth.	Interval in miles.		Width of stream.	Depth in channel.	Current per hour.	Bends per mile.	Diameter of bends.	Height of left side.	Height of right side.	Height of ordinary freshet.	Reported height of water, at time of examination, above dead low water.	Estimate of cost of improvement by snagging and clearing to present natural dimensions.
			Feet.	*Feet.*	*Miles.*	*No.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
0	.....	Mouth in Tar River	40	6+	1.0	....	.....	10	6	10	2	.....
3.1	3.1	Hargrove's Bridge..	40- 80	6+	1.0	7	200-1,000	3-15	3-06	8-10	2	$2,000
6.6	3.5	Sessom's Bridge ...	40-120	4+	0.5	6	200-1,600	6-20	9-18	10	2	700
13.0	6.4	Savage's Bridge	40-120	4+	1.0	7	100-1,200	6-35	4-20	8-10	2.5	1,800
18.1	5.1	Coffield's Bridge....	40-100	6+	1.5	10	100- 800	7	6-09	7	2.5	2,000
19.3	1.2	Bellamy's New Bridge	40-100	6+	1.5	12	100- 600	7	3-20	7	2.5	600
24.8	5.5	Spier's Bridge	40-100	6+	1 5	10	100- 800	5- 7	3-25	7	2.5	3,500
30.1	5.3	Pittman's Bridge ...	60-100	6+	1.0	7	100-1,200	4- 6	3-05	5	3.5	3,500
34.3	4.2	Daniel's Bridge.....	50- 90	5+	1.5	7	100-1,500	5-10	7-10	8	3.5	4,000
34.5	0.2	W. and W. R. R. Bridge.....	90	6+	0.5	1	4,000	8	10	10	4	100
38.1	3.6	Bellamy's Bridge ...	50-100	6+	1.0	6	300-2,000	7-12	6-50	10-12	4	1,800
38.2	0.1	Bellamy's mill-dam.	120	10	1.5	....	.....	12	12	15	5	.....
												20,000
		Superintendence and contingencies ...	.....	.....	.....	....	.....	.....	.....	.....	.....	5,000
		Total	.....	.....	.....	...	.....	.....	.....	.....	.....	25,000

The lands on both sides of this stream are agriculturally rich, and are well adapted to the culture of grains, grasses, vegetables, tobacco, and cotton, and to the raising of live stock. The forest lands of this region contain much valuable timber, such as gum, cypress, hickory,

all varieties of oak, pine, etc., most of which is uncut because of no easy means of transport to market. The farms adjacent to this stream, between Bellamy's Mill and its mouth, and within 5 miles of its banks, are estimated to embrace 120,000 acres of land, only about 40,000 of which are at present under cultivation. What they most need at present is more transportation facilities. The present commerce of this section is that of from forty to sixty stores and of from seventy-five to one hundred large farms, and is estimated at $500,000 of products (10,000 bales of cotton, besides other crops) and $400,000 of imports (fertilizers, machinery, and general merchandise). These products and imports would both be very much increased if there were some means of easy transportation outward for farm products and inward for fertilizers and machinery. On the Tar River (into which this stream empties) during the last ten years each dollar spent upon the improvement of the river navigation has been accompanied by the development of $32 in annual commerce, and the freight charges have in the same interval fallen by from 12 to 25 per cent. Similar or even better results may naturally be expected from the opening of this stream, which can be done by the mere removal of snags and fallen trees from its channel and leaning and overhanging trees from its banks, at an expense roughly estimated as stated in the above table.

Under these circumstances, I regard this stream as worthy of improvement by the General Government, so far as to clear out its natural obstructions from its mouth up to Bellamy's Mill, at a total expense of about $25,000.

The above estimates are based upon past work on neighboring rivers. They include all allowances for necessary superintendence and contingencies, and they are herewith submitted as being a sufficient indication of the amount of the needed appropriations. More precise surveys and estimates of cost can be advantageously postponed until work is in actual progress on this stream.

For advantageous work the necessary funds should be voted at the rate of about $10,000 or more per year. Smaller or irregularly voted appropriations will involve the alternate organization and disorganization of working parties, extra superintendence, deterioration of plant, and extra cost of moving plant over long distances to and from the place of work, and will considerably increase the final cost of the work.

Respectfully submitted.

W. H. BIXBY,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

M 18.

PRELIMINARY EXAMINATION AND SURVEY OF THE NORTH EAST RIVER (CAPE FEAR), NORTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
Wilmington, N. C., November 25, 1889.

GENERAL: I have the honor to submit herewith the following report upon the examination and survey of the North East River (Cape Fear), North Carolina, ordered by river and harbor act of August 11, 1888,

and assigned to me by letters from your office dated August 28 and September 29, 1888.

The following report is based upon information obtained either by letter or word of mouth from various persons living upon this river or interested in its navigation, as checked and assisted by my own general knowledge of the neighborhood and by my own detailed boat inspection and rough maps of the 103 miles of river between its mouth and Kornegay's Bridge, N. C.*

The North East (Cape Fear) River rises in the extreme northern part of Duplin County, flows in a general southerly direction through Pender and New Hanover counties, and empties into the main Cape Fear River at Wilmington, some 30 miles from the ocean. It has a total length of about 130 miles (70 miles in a straight line) and of about 1,600 square miles of drainage area.

Over its lower 50 miles this river is tidal, with a depth of at least 6 feet at all stages of tide and water, and easily navigable by small steamers, even when carrying two small flats abreast. Over the next 40 miles (from near Bannerman's Bridge to near Hallsville) this river has a depth of about 3 feet at ordinary stages, flows between banks of moderate height, has a gentle slope, and is suitable to navigation by small stern-wheel 30-ton to 50-ton steam-boats such as are now in use on similar streams in other parts of the State. Over the next 13 miles (up to Kornegay's Bridge) the banks become lower, the stream shallower, narrower, and crookeder, and suitable mainly for the use of pole-boats and rafts. Above Kornegay's Bridge the stream may be used by pole-boats, but to less advantage.

Between Kornegay's Bridge and its mouth this river receives several tributaries: Burncoat, Panther, Goshen, Grove, Persimmon, Limestone, Maxwell, Muddy, Cypress, Island, Oakey, Rockfish, Angola Swamp Canal, Fishing, Hollyshelter, Burgaw, Harrison, Island, Holly, Sturgeon, and Lillington, bringing in a moderate amount of water at all times of the year, and larg · quantities during freshets, and used during a large part of the year by small boats, pole-boats, and rafts.

Along this part of the river, and at intervals of from 6 to 10 miles, are several settlements: Kornegay's, Sarecta, Hallsville, Chinquapin, Washington, Kroom's, Murrayville, Bannerman's, Rocky Point, Harrison, Castle Hayne, at most of which are stores, turpentine stills, cotton-gins, grist-mills, and saw-mills.

This portion of the river is crossed by seven county bridges and one railroad bridge, of which the railroad bridge and the upper three county bridges are without draws.

A small steamer of about 5-foot draught makes bimonthly trips at present over the lower 48 miles of river to Bannerman's Bridge. More frequent trips are not made because the present blocked condition of the upper river prevents navigation and the descent of commerce, except during freshets. Another small steamer has lately succeeded in getting up 88 miles, to Hallsville, being troubled more by snags and trees than by want of depth and breadth of channel.

The general features of the river are shown in more detail in the following table, based upon my own personal examination and maps:

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* Sketch accompanying this report omitted, but is printed in House Ex. Doc. No. 35, Fifty-first Congress, first session.

Distances.		Locality.	Observed.										
			Water-way.			Curvature.		Banks.					
Miles from mouth.	Interval in miles.		Width of stream.	Depth in channel.	Current per hour.	Bends per mile.	Diameter of bends.	Height of left side.	Height of right side.	Height of ordinary freshet.	Reported height of water, at time of examination, above dead low water.	Estimate of cost of improvement by snagging and clearing to present natural dimensions.
			Feet.	*Feet.*	*Miles.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
0	....	Wilmington	800	16	0–3	....	.....	30	4	5	.....	.....
35.1	35.1	Rocky Point	400–1,200	6–30	0–1	1	1,000–4,000	1–10	1–10	3	1	*†$4,000
48.1	13.0	Bannerman's	90– 400	6 +	0–1	4	200–3,000	3–35	2–12	6	1	*2,000
56.1	8.0	Kroom's	90– 180	6 +	0–1	4	200–4,000	5–20	8–30	5–10	1	*2,400
60.1	4.0	Old Washington	90– 150	3.5+	0–1	4	200–1,500	10–20	11–18	12	0.5	*1,200
74.9	14.8	Deep Bottom Bridge	80– 150	1.5+	0–1	7	200–1,500	3–50	5–35	10–15	0.5	*5,000
79.1	4.2	Chinquapin	90– 150	3 +	0–1	9	150– 800	4–40	5–15	8–13	0.5	*1,600
88.4	9.3	Hallsville	70– 150	1– 6	0–1	9	100– 800	6–20	5–18	9–13	1.0	*2,800
97.6	9.2	Sarecta	20– 110	2– 4	1.5	14	100– 800	1– 8	1– 9	4– 8	2.0	‡3,500
103.4	5.8	Kornegay's	20– 60	3– 8	1.5	20	50– 500	1–60	1–10	2– 4	2.0	‡1,500
												24,000
		Superintendence and contingencies	.....	.....	.....	....	.....	.....	.....	.....	.....	6,000
		Total	.....	.....	.....	....	.....	.....	.....	.....	.....	30,000

* For steamers.
† Including $700 for removal of old bridge piers at Wilmington.
‡ For pole-boats.

The lands on both sides of the river are good, agriculturally, and well adapted to the culture of grains, grasses, vegetables, cotton, and to the raising of live stock. What they most need, especially on the eastern side of the upper river, is cheap transportation facilities. Cotton, naval stores (turpentine, tar, rosin), and timber are the most important products. The timber lands are extensive, and embrace a large variety of pine, oak, hickory, cypress, juniper, gum, bay, cedar, willow, beech, birch, walnut, cherry, mulberry, persimmon, poplar, maple, elm, etc. For the last eight or ten years much of the finer timber has been shipped to Holland and Brazil. The farm products of this region include tobacco, corn, oats, rice, wheat, rye, pease, beans, pea-nuts, Irish potatoes, sweet-potatoes, squashes, turnips, melons, cabbages, berries, dog-tongue, etc.

The total commerce of the river is estimated as follows:

Commerce of North East (Cape Fear) River Basin.

Articles.	Kornegay's.	Sarecta.	Hallsville.	Chinquapin.	Deep Bottom.	Bannerman's.	Lower river.	Totals.
Cotton	$40,000	$25,000	$15,000	$9,000	$5,000	$5,000	$30,000	$129,000
Timber and products	3,000	5,000	25,000	25,000	20,000	25,000	1,000	104,000
Naval stores	12,000	12,000	26,000	30,000	10,000	30,000	2,000	122,000
Live stock	2,000	3,000	5,000	2,000	2,000	1,000	5,000	20,000
Fruits, vegetables, etc	10,000	11,000	4,000	5,000	1,000	3,000	10,000	44,000
Fertilizers	.....	.....	.....	.....	.....	.....	10,000	10,000
Total products	67,000	56,000	75,000	71,000	38,000	64,000	58,000	429,000
Imports, fertilizers, and general merchandise	60,000	50,000	70,000	65,000	35,000	60,000	50,000	390,000
Grand total	127,000	106,000	145,000	136,000	73,000	124,000	108,000	819,000

Much more would be produced if there were some means of easy and cheap transportation, outward for the farm products and inward for fertilizers, machinery, and general merchandise.

In my reports of 24th October, 1884, and 14th February, 1885, upon an examination of this same stream, I recommended against its improvement at that time, on the ground that the river was then already improved ahead of the demands of its commerce. My recent examinations show me that I had underestimated the quality and extent of the cultivated lands of the upper river, their existing and possible products, and the difficulties of navigation of this upper river. Moreover, I have in the last four years become somewhat more familiar with the difficulties of transportation in this locality and far more familiar with the rapid development of country and commerce which rapidly follow the opening up of light-draught transportation routes in this neighborhood. On the similar rivers of this district within the last ten years, each dollar once spent in the improvement of the river navigation has been accompanied on the average by the development of about $20 in annual commerce, and the freight charges have correspondingly fallen by from 12 to 25 per cent. Similar results may naturally be expected from the opening of this upper river, which can be done by the mere removal of snags and fallen trees from its channel and leaning and overhanging trees from its banks, at an expense roughly estimated as stated in the above table.

Under these circumstances I now regard the North East (Cape Fear) River, North Carolina, as worthy of improvement by the General Government, so far as to clear out its natural obstructions from Wilmington up to Kornegay's Bridge, at a total expense of about $30,000.

The above estimates are based upon past work on neighboring rivers; they include allowances for necessary superintendence and contingencies, and they are herewith submitted as being a sufficient indication of the amount of the needed appropriations. More precise surveys and estimates of cost can be advantageously postponed until work is in actual progress on this part of the river.

For advantageous work the necessary funds should be voted at the rate of about $10,000 or more per year. Smaller or irregularly voted appropriations will involve the alternate organization and disorganization of working parties, extra superintendence, deterioration of plant, and extra cost of moving plant over long distances to and from the place of work, and will considerably increase the final cost of the work.

Respectfully submitted,

W. H. BIXBY,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

M 19.

PRELIMINARY EXAMINATION OF SHALLOTTE RIVER, NORTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
Wilmington, N. C., September 13, 1889.

GENERAL: I have the honor to submit herewith the following report upon the examination of Shallotte River, North Carolina, ordered by river and harbor act of August 11, 1888, and assigned to me by letters from your office August 28 and September 29, 1889.

This report is based upon my own personal inspection of the locality and upon information obtained either by letters or word of mouth from various parties living around Shallotte Inlet, the whole being checked by an examination of the U. S. Coast Survey charts and by my own personal knowledge of the case.

Shallotte River is a stream of about 30 miles length and 60 square miles of drainage basin, lying wholly in Brunswick County, N. C. It rises at a point about 30 miles soutwest of Wilmington, N. C., flows in a general southeasterly direction, and empties into the Atlantic Ocean at a point about 20 miles west of the mouth of the Cape Fear River.

At its ocean bar its least channel depth is about 3½ feet at low water and 7 feet at high water; from the bar to a point 2 miles above its mouth this depth is about 5 feet at low water; for the next 1½ miles it varies from 1 to 2 feet at low water and from 4 to 7 at high water, according to circumstances of wind and tides, with a bottom of alternate mud and oyster-rock shoals; for the next 11 miles it is from 3 to 10 feet at low water. Coasting schooners of 250 barrels or 22 tons capacity, of about 50 feet length, 16 feet width, and 4.7 feet draught, enter the river from the ocean at favorable tides and go 14 miles up the river. At the head of the schooner navigation the river is still about 40 feet wide. From this point pole-boats might carry merchandise a few miles farther. At the head of present schooner navigation the river is crossed by a bridge without a draw; but no bridges of any sort exist across this stream between the head of schooner navigation and the ocean.

At present the commerce of the river is small. The exports (crude and manufactured turpentine, tar, wood, light-wood, lumber, cotton, rice, corn, sweet-potatoes, ground peas, fish, oysters, diamond-backed terrapin) are estimated at about $50,000 per year, and the imports (general merchandise) at about $30,000 more; total, $80,000 per year.

The details of this commerce are stated as follows by Mr. P. Rourk, sheriff and principal merchant of Shallotte:

Exports from Shallotte River for the calendar year of 1887.

Spirits turpentine, 1,134 casks, at $20	$22,680.00
Rosin, 4,678 barrels, at $1	4,678.00
Strained tar, 600 casks, at $3.75	2,250.00
Crude tar, 182 barrels, at $1.60	291.20
Fish, 192 (large) barrels, at $8	1,536.00
Crude turpentine, 250 barrels, at $2.10	525.00
Cotton, 130 bales, at $45	5,850.00
Peanuts, 2,020 bushels, at 90 cents	1,818.00
Potatoes (sweet), 500 bushels (approximately), at 50 cents	250.00
Peas (cow), 100 bushels (approximately), at $1.25	125.00
Chickens and other poultry, 1,000 (approximately), at 25 cents	250.00
Eggs, 10,000 dozen (approximately), at 20 cents	2,000.00
Oysters, 2,000 bushels (approximately), at 75 cents	1,500.00
Miscellaneous articles (approximate)	2,500.00
	46,253.20

These goods are carried away at present by schooners, one of which endeavors to make two trips per week to Wilmington. The oyster-rock barrier, combined with unfavorable tides, sometimes detains this schooner as much as ten days at a time, so that regular trips become an impossibility, and the commerce, as a consequence, suffers severely. The deep sandy roads and long distances by land to the nearest railroads would reduce the farmer's profits to almost nothing if they were obliged to transport their goods to market by land and rail. Owing to

this difficulty of getting goods to market only about 1,300 acres of upland and 500 acres of swamp land are at present under cultivation.

The Shallotte River basin, though small, is, comparatively speaking, good agriculturally. It embraces within 4 or 5 miles of the river bank, at least 4,000 acres of good uplands and 3,000 acres of good swams land, capable of producing ordinarily from $20 to $40 of ordinary crop per acre, representing about $270,000 of possible annual crops. Besides this agricultural wealth the basin contains a large quantity of pine, oak, ash, hickory, gum, cypress, and juniper in standing timber. Were the obstructions removed from the mouth of the river the annual commerce would probably soon reach $160,000 to $200,000 per year, a gain over the present of from $80,000 to $120,000 per year.

The needed improvements are only the removal of the oyster-rock barricade near the mouth of the river. Ten thousand dollars will give valuable results; $20,000 will probably complete all needed improvements for several years to assure to this river from its head of navigation down to the ocean a channel depth of water sufficient to allow the free passage of all boats that can now cross its ocean bar.

In my opinion, the probable increase in the commerce of this river and in the development of its basin renders this river worthy of improvement by the General Government to the extent above indicated.

The exact location and the cost of the improvement can only be definitely determined by a special survey, estimated to cost $300 or less, and which can be made with the funds already in my possession.

Very respectfully, your obedient servant,

W. H. BIXBY,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

SURVEY OF SHALLOTTE RIVER, NORTH CAROLINA.

UNITED STATES ENGINEER'S OFFICE,
Wilmington, N. C., December 12, 1889.

GENERAL: In accordance with instructions from your office, dated April 1, 1889, and the river and harbor act of August 11, 1888, I have herewith to submit my report upon the survey of Shallotte River, North Carolina, with a project for its improvement and an estimate of the cost of such improvement.

This project and estimate of cost are based upon a survey of the portion needing improvement, as made by Surveyor H. G. Myrover, his maps being checked and completed by the U. S. Coast and Geodetic Survey of 1858–'59 and as further checked by an inspection of the locality by myself in person in a row-boat at both high and low water.

The present commercial interests of the locality are as previously stated by me in my report of September 13, 1889, on its preliminary examination, viz, a present commerce of about $80,000 per year and the prospect of developing from $80,000 to $120,000 more per year by the recommended improvement of its water-way.

Shallotte is 30 miles distant from the nearest railroad and 20 miles from the nearest improved ocean inlet; so that it and the surrounding country is almost entirely dependent for easy transportation upon the facilities of its own river and outlet to the ocean.

The needed improvements are (1) the straightening of the channel and removal of oyster-rock shoals over 9,000 feet of channel in the wide estuary portion of the river (from 2½ to 4½ miles above the ocean bar) and (2) the removal of 5 short oyster-rock shoals (total, 700 feet length) in the upper river, at points as indicated on the accompanying map. It is estimated that this can be done so as to give a clear channel of 60-foot width and 4-foot depth at low water at a cost as follows:

60,000 cubic yards of mud (with 10 per cent. oyster shells), at 40 cents per cubic yard	$24,000
Superintendence, contingencies, etc., 25 per cent	6,000
Total	30 000

These estimates are based upon past experience on similar improvements of this district. The first $10,000 will give valuable results in improving the present navigation and the next $10,000 will possibly open up a full-depth channel of sufficient width for advantageous use and equal to the available depth on the ocean bar.

I have, therefore, to recommend the improvement of this river by the General Government to the extent of $30,000, as above estimated. For advantageous work, the necessary funds should be voted at the rate of $10,000 or more per year. Smaller or irregularly voted appropriations will involve the alternate organization and disorganization of working parties, extra superintendence, deterioration of plant, and extra cost of moving plant over long distances to and from the place of work, and may considerably increase the final cost of the work.

Respectfully submitted,

W. H. BIXBY,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. H. G. MYROVER, SURVEYOR.

UNITED STATES ENGINEER OFFICE,
Wilmington, N. C., October 3, 1889.

CAPTAIN: I have the honor to submit the following report of a survey of Shallotte River, North Carolina.

* * * * * * *

The field work of the survey was commenced on September 14, 1889, and finished on September 26, 1889. Maps of the shoal portions of the river, on a scale of 200 feet to the inch, were made during the progress of the work, and a map of the river from Shallotte Bridge to the shoals (about 7 miles) was made upon a scale of 1,000 feet to the inch. All of these maps* are submitted herewith.

Tide-gauge observations were kept and recorded daily at the gauge located at Moore's Landing. The detailed surveys were made by compass bearings and stadia measurements, and the soundings taken with a 12-foot rod at intervals along a floating measuring-line of 600 feet length, tagged at intervals of 30 feet, stretched across the channel-ways surveyed.

The water on the bar is said to vary in depth from 3½ feet to 7 feet. From the bar to Negro Field landing there is an available channel of over 6 feet depth. Thence to a point 3,000 feet further there is an available depth of 4 feet in the channel. From this point to Wild Horse the channel is obstructed by shoals composed of mud and shell rock, over which there is a continuous available depth of only about .5 feet. The tide flows over these shoals at a uniform velocity of apparently about 3½ miles per hour.

The shell rock seems to be only so far below the surface of the mud upon which it

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*Omitted; printed in House Ex. Doc. No. 78, Fifty-first Congress, first session.

rests as it reaches through its own weight (apparently about 6 inches) and can be removed at little more cost than mud.

From Adams Hole (the point of commencement of detailed surveys) the river was surveyed and sounded by floating-line and pocket compass, and, with the exception of five shoals (which were surveyed in detail and plotted on a scale of 100 feet to the inch), shows an available channel depth of 6 feet at low water to Shallotte Bridge.

* * * * * * *

Very respectfully, your obedient servant,

H. G. MYROVER,
Surveyor.

Capt. W. H. BIXBY,
Corps of Engineers, U. S. A.

APPENDIX N.

IMPROVEMENT OF LUMBER RIVER, NORTH CAROLINA, OF WACCAMAW RIVER, NORTH CAROLINA AND SOUTH CAROLINA, AND OF RIVERS AND HARBORS ON THE COAST OF SOUTH CAROLINA.

REPORT OF CAPTAIN FREDERIC V. ABBOT, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1890, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

IMPROVEMENTS.

1. Charleston Harbor, South Carolina.
2. Lumber River, North Carolina.
3. Mingo Creek, South Carolina.
4. Clark Creek, South Carolina.
5. Ashley River, South Carolina.
6. Edisto River, South Carolina.
7. Salkiehatchie River, South Carolina.
8. Little Pee Dee River, South Carolina.
9. Great Pee Dee River, South Carolina.
10. Santee River, South Carolina.
11. Wateree River, South Carolina.
12. Congaree River, South Carolina.
13. Wappoo Cut, South Carolina.
14. Waccamaw River, North Carolina and South Carolina.
15. Removing sunken vessels or craft obstructing or endangering navigation.

EXAMINATIONS AND SURVEYS.

16. Beaufort River, South Carolina.
17. Owendaw and Wando rivers and other waters and water routes connecting Bull's Bay and the harbor of Charleston, South Carolina.

UNITED STATES ENGINEER OFFICE,
Charleston, S. C., July 8, 1890.

GENERAL: I have the honor to transmit herewith the annual reports for the fiscal year ending June 30, 1890, for the works of improvement of rivers and harbors which have been in my charge.

Very respectfully, your obedient servant,

FREDERIC V. ABBOT,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

N 1.

IMPROVEMENT OF THE HARBOR AT CHARLESTON, INCLUDING SULLIVAN'S ISLAND, SOUTH CAROLINA.

REFERENCE TO PAST REPORTS.

For history of past operations up to June 30, 1888, see pages 970 to 979, Annual Report, Chief of Engineers, U. S. Army, for 1888. For Report of Board of Engineers and modified project including estimate, see Annual Report, Chief of Engineers for 1889, pages 1150 to 1155.

The present lengths of the jetties are as follows: North jetty, 14,327 fee; south jetty, 16,440 feet.

ORIGINAL CONDITION.

There were four channels across the bar, the deepest having about 12 feet at low water.

PLAN OF IMPROVEMENT.

It is proposed to establish and maintain by means of two jetties a low-water channel of not less than 21 feet across the bar. The action of the jetties is to be assisted by dredging.

The estimated cost of the project is $4,380,500 if the jetties are left at mean low-water level throughout; if brought up to 3 feet above mean low-water level throughout, $5,334,500.

The aggregate amount appropriated for this work up to June 30, 1890, is $1,832,500.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

Work under the contract with Messrs. Grant & Egan has continued throughout the year. Twenty-one thousand three hundred and fifty-three short tons of rip-rap have been deposited during the year at the outer end of the north jetty, raising about 3,000 feet practically to low-water level, and 34,012 tons of rip-rap have been deposited on the south jetty, between points 7,000 feet and 12,300 feet from the present shore end, raising this portion of the jetty practically to low-water level.

On both jetties, all the stone has practically been deposited on the center line, so as to secure as steep side slopes as possible. The crest width at low-water level being about 10 feet, the object has been to concentrate the water at the present time as much as possible with the funds available with the definite idea that the work now done will be leveled off very considerably by the waves, and will have to be raised again after it has attained a condition of stability.

The dredge first supplied by Mr. B. C. Howell under his contract was a self-propelling pump-dredge arranged to load scows. As soon as work began, it became apparent that the plant was ill adapted to the work, as the dredge and scows were continually coming into contact under the action of the waves. A new dredge was begun for the work, but financial troubles in which the company were involved delayed progress, and the new dredge did not report at Charleston till June 17, 1890. The first dredge was kept at work as often as weather permitted, till May 12, when she was so injured that she had to be taken off for repairs.

During the year 56,626 cubic yards have been dredged and dumped.

Mr. Howell deserves a great deal of credit for keeping his dredge,

which was an expensive and fine piece of machinery, so long at work when she was being very seriously injured, in order to comply with the requirements of his contract. While his progress has been very slow and unsatisfactory, it is believed that he has done everything that was possible with the plant he had here and that he supplied a new and better plant as soon as he was financially able to do so.

With the view of insuring more rapid and economical work, authority was asked, and granted in May, 1890, to purchase a plant to do rock-work on the jetties by hired labor in addition to contract work. The plant has been obtained and consists of a very powerful tug, eight lighters 80 feet long, 22 feet wide, and 6 feet depth of hold, and a derrick scow 115 feet long, 36 feet wide and 7 feet deep, with a Ledgerwood hoisting engine capable of raising 8,000 pounds on the running line and operating a turn-table derrick capable of raising and swinging 10 tons of rock.

Reasonable freight arrangments have been made with the South Carolina Railway. This railway also provides free a fine terminal wharf in this city. Three powerful hoisting engines have been procured, two for the quarries and one for loading lighters from the cars. A quarry-site has been obtained and quarry work started at Edgefield, S. C.; the stone is a compact granite. These arrangements were made so late in the fiscal year that practically no work has been done by hired labor as yet. The material used on the jetties from the beginning of operations to June 30, 1890, is as follows:

	Stone.		Mattress.
	Tons.	*Cu. yards.*	*Sq. yards.*
North jetty	22,644	122,335	175,155
South jetty	34,012	143,414	306,585
Total	56,656	265,749	481,740

No material changes in the condition of either jetty have occurred during the past fiscal year, except such as are due to work done in that period.

The annual survey of 1889 showed the existence of several small holes with more than 12 feet of water in them on the main outer shoal between the jetties. The survey of 1890 shows that these deep holes have increased in size, and have become somewhat merged into each other, so that a 12-foot channel can now be carried all the way through, except for a space of about 600 feet. A large part of this deepening on the outer shoal has taken place so far from the dredge range that it can not be due to the dredging. The area on which there is less than 12 feet of water decreased 30 acres in extent between May, 1889, and May, 1890. With a view to showing clearly to the eye the great changes which have occurred in the area between the jetties, a chart has been prepared giving a comparison of the surveys of 1884 (the first very accurate survey), and of 1890. This chart shows a very marked decrease of area on which there is less than 9 feet of water at mean low tide, and a rapid movement of these shoals seaward under the action of the ebb tide. It also shows that the former 12-foot channel, which was cut off by the north jetty, has now assumed a position nearly parallel with the jetty passing, except for a distance of 600 feet, in which there is now 10½ feet, right through the Old Swash Reef, on which there was not over 8 feet of water in 1884.

If the dredge had been able to work as rapidly as the contract called for, there can be no reasonable doubt that a straight channel at least 12 feet in depth would have been produced.

The contract called for the removal of about 300,000 cubic yards by this time, and only about one-fifth of that amount of work has been done. The deep water inside of Jim Evans Shoal has followed the shoal down in a very satisfactory manner, and the 18-foot curve in front of the jetties has not been pushed seaward at all. Morris Island has hardly changed at all during the year.

For details of work done, and discussion of the curves and profiles derived from this year's survey, reference is made to report of Mr. Allen, who deserves much credit for zealous and efficient work.

APPROPRIATIONS.

In the twelve years which have elapsed since the first appropriation was made funds have been provided at an average rate of $152,708 per year, or less than 3 per cent. of the amount of the least revised estimate. It is evident that rapid completion of the work, proper economy in carrying it out, and early benefit therefrom can not be looked for with a system of insufficient appropriations. I most emphatically repeat the recommendation which has been made in each annual report for this work that annual appropriations of from $500,000 to $750,000 be made, with a view to speedily and economically completing this important improvement.

With the balance of $233,900.32 on hand July 1, 1890, work will be prosecuted in accordance with the revised project, under the contracts with B. C. Howell for dredging, and Grant & Egan for stone-work. Stone-work will also be done by hired labor and purchase of material in open market, with the balance of funds in hand not covered by these two contracts.

This work is in the collection district of Charleston, S. C., which is the port of entry. The amount of duties collected in the calendar year of 1889 is $16,728.82.

Since the existing project of improvement has been adopted the following appropriations have been made:

By act of Congress approved—	
June 18, 1878	$200,000
March 3, 1879	200,000
June 14, 1880	170,000
March 3, 1881	175,000
By act of Congress passed August 2, 1882	300,000
By act of Congress approved—	
July 5, 1884	250,000
August 5, 1886	187,500
By act of Congress of August 11, 1888	350,000
Total	1,832,500

Of this amount there has been expended from the beginning of operations to and including June 30, 1890, the sum of $1,598,599.68, which includes the cost of building shore protections on Sullivan's Island and Mount Pleasant.

The following drawings and papers accompany this report:

Sheet 1. Showing the jetties and latest soundings to June 30, 1890.
Sheet 2. Longitudinal profiles through Jetty Channel, constructed from mean soundings.
Sheet 3. Comparison of surveys of 1884 and 1890.
Report of Mr. James P. Allen, assistant engineer.
Table of commercial statistics furnished by the collector of the port.

Sullivan's Island

high water line June 1890

low water line June 1890

FORT SUMTER

TRUE MERIDIAN

CENTRAL RANGE

No.5

No.6

No.4

No.1

No.2

No.3

SOUTH JETTY

NORTH JETTY

DREDGE CUT

Deep Pocket

BELL BUOY

Morris Island

low water line

high water line

Jan. May 1880

Jan. May 1890

IMPROVING HARBOR AT CHARLESTON S. C.

SHEET 1

showing the jetties and latest soundings to June 30, 1890.

UNDER THE DIRECTION OF

CAPTAIN FREDERIC V. ABBOT,

CORPS OF ENGINEERS U.S.A.

JAMES P. ALLEN,

ASSISTANT ENGINEER.

SCALE OF FEET.

1000 0 1000 2000 3000 Ft.

The soundings are in feet and tenths and are referred to mean low water.

The 18 ft curve is shown thus: ... ...

The 15 ft. " " " " : — — — —

The 12 ft. " " " " : ————

The 9 ft. " " " " : — · — · —

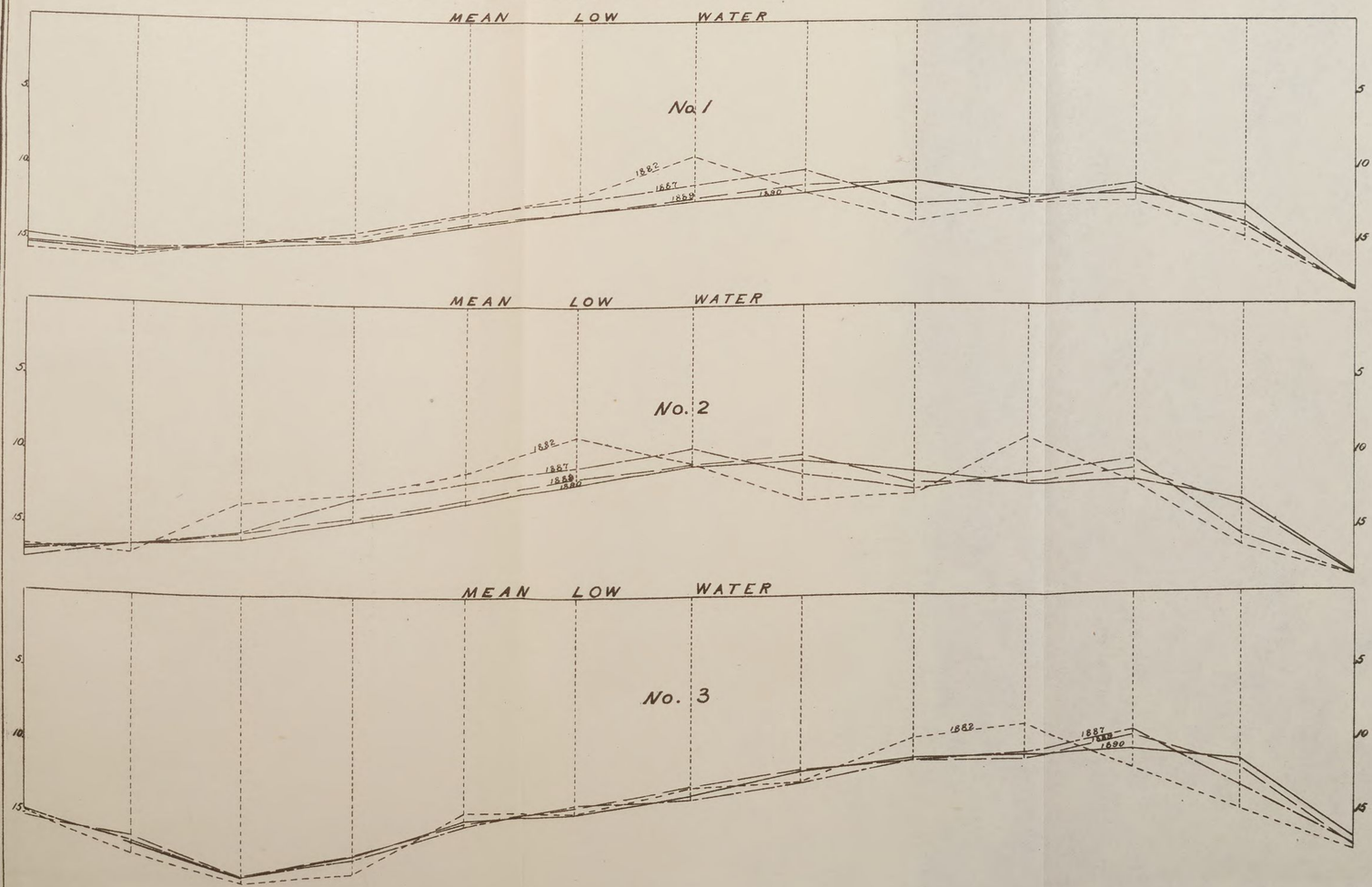
Current measurements were made at points shown thus: ⊕ No 1.

Portions of the jetties raised during the year are indicated by a heavy line.

Accompanying annual report of 1890.

Frederic V. Abbot

Captain of Engineers U.S.A.



SHEET No. 2

PROFILES FROM MEAN SOUNDINGS

No. 1 IS FROM SOUNDINGS NEAR THE NORTH JETTY
No. 2 " " " MIDWAY BETWEEN JETTIES
No. 3 " " " NEAR THE SOUTH JETTY.

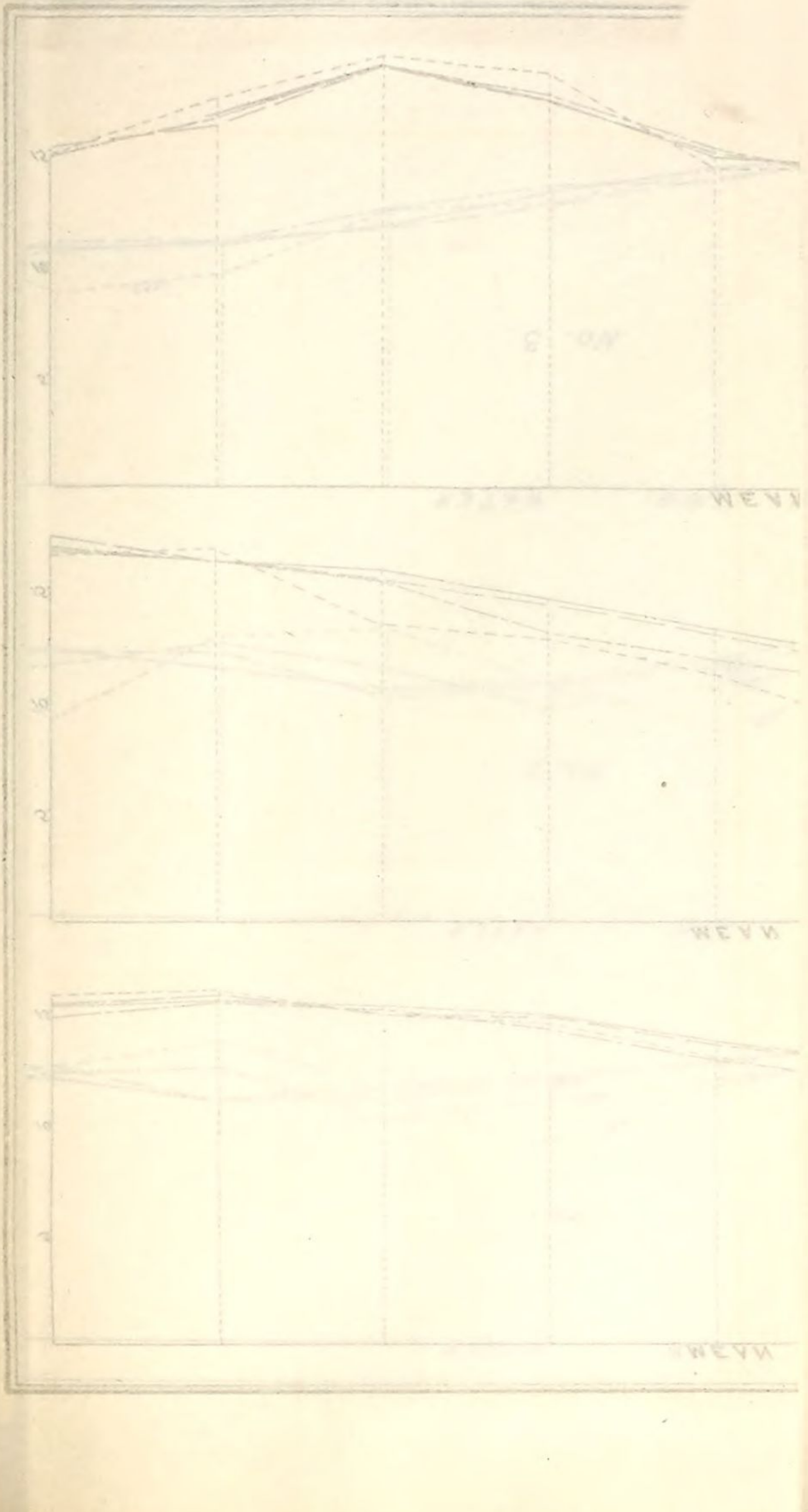
HOR. SCALE
1000 0 1000 2000 FT.

VERT. SCALE
5 10 15 20 25

NOTE
THE PROFILE FOR 1882 IS SHOWN THUS - - - - - - - - - -
" " " 1887 " " " ——————
" " " 1889 " " " — — — —
" " " 1890 " " " ————————

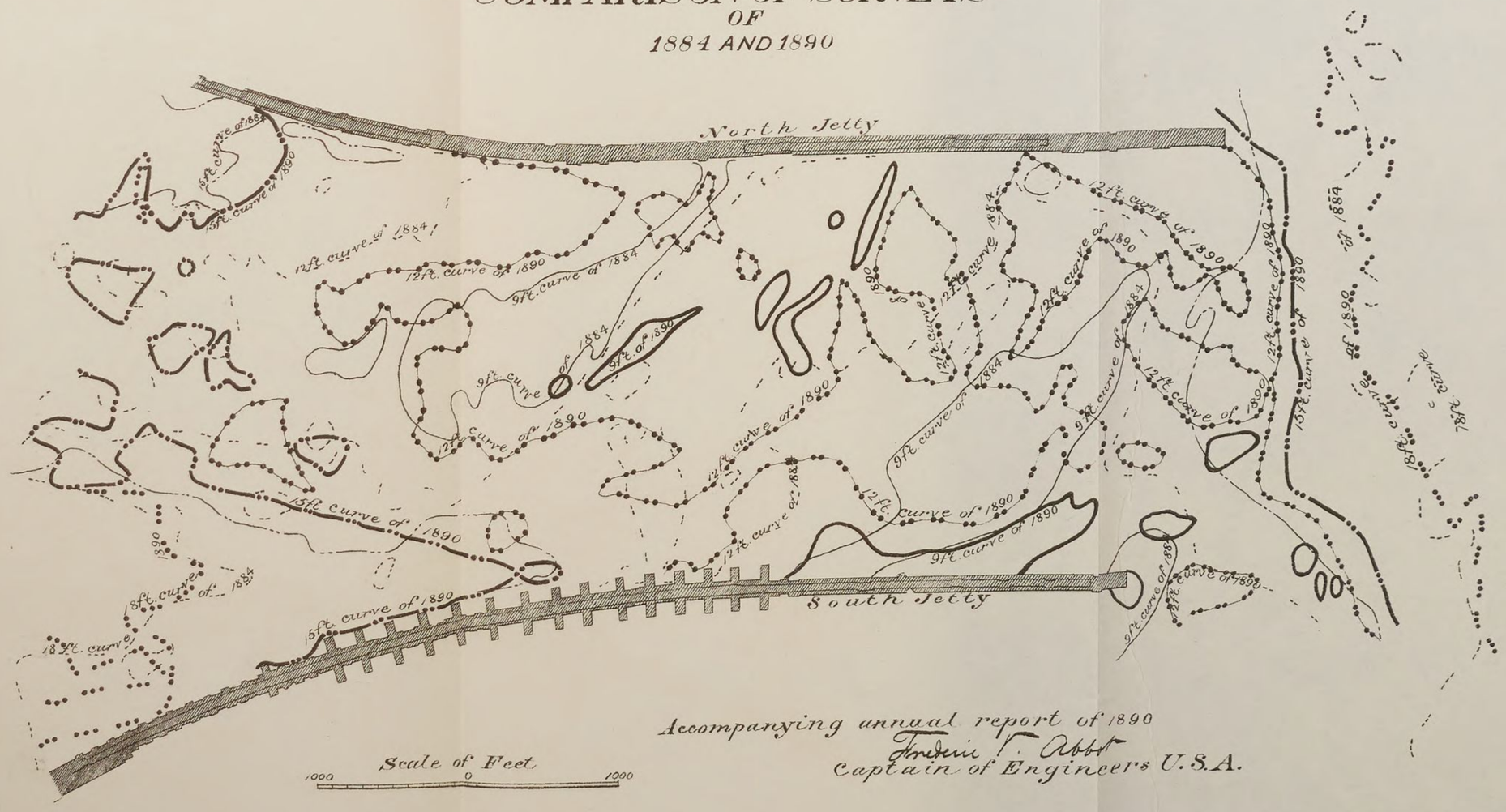
Accompanying annual report of 1890

Frederic V. Abbot
Captain of Engineers U.S.A.



SHEET No.3

COMPARISON OF SURVEYS
OF
1884 AND 1890



Accompanying annual report of 1890
Frederic V. Abbot
Captain of Engineers U.S.A.

Money statement.

July 1, 1889, amount available		$76,618.44
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$24,837.73	
July 1, 1890, outstanding liabilities	19,712.21	
		44,549.94
July 1, 1890, balance available		32,068.50
Amount appropriated by act of September 19, 1890		370,000.00
Amount available for fiscal year ending June 30, 1891		402,068.50
Amount (estimated) required for completion of existing project		2,178,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		750,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. JAMES P. ALLEN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Charleston, S. C., June 30, 1890.

CAPTAIN: I have the honor to submit the following report upon the improvement of the Charleston Harbor, South Carolina, for fiscal year ending June 30, 1890.

Work was carried on continuously upon the jetties under the contract of Grant & Egan for raising both jetties with stone. Twenty-one thousand three hundred and fifty-three tons of stone have been placed on the outer 3,000 feet of the North Jetty, and 34,012 tons of stone on the South Jetty, from 7,000 feet to 12,300 feet from the present shore end. The intention is to bring the jetties over these portions up to low water with a 10-foot crest, by piling the stone up to half-tide upon a central range. For the first 700 feet on the South Jetty, that is from 7,000 to 7,700 feet from shore end, the work was not brought up to low water, but was raised upon a gradual slope as nearly as this could be done; the larger part of the stone being used under this contract is brought from the interior of the State of South Carolina and from North Carolina by rail; whereas, heretofore, most of the stone has come from the vicinity of New York by vessels.

Dredging between the jetties, under the contract of Mr. B. C. Howell, was begun September 9, 1889, and continued without serious intermission until May 12, 1890. The plan pursued by this contractor, of towing large dumping scows along-side of his dredge-boat, has not proved satisfactory. The occasions when it is smooth enough to work in this manner without damage to the dredge-boat are rare, and the dredge-boat *Herbert* was so badly used up by constant thumping of these lighters against her side that she was removed by the contractor and sent to Nicaragua to work in still water.

The quantity of material removed during the year was 56,626 cubic yards. The contractor intended to replace the *Herbert* with another dredge as soon as possible. This dredge arrived on June 17, but had done no work by the 30th of June, 1890. She carries her own dredgings in bins forward, and has machinery similar to the *Herbert*. She is not self-propelling, but will require to be towed.

SURVEYS AND CROSS-SECTIONS.

Some cross-sections of the North Jetty were made in September and October, 1889, in order to determine the slopes which the riprap stone maintained under the action of the waves. Beginning in November, 1889, and extending into March, 1890, a series of observations was made of the currents in the Swash and main ship channels. Three points were selected in the Swash Channel; numbered 1, 2, and 3, respectively. Number 4 is in the pocket east of the main ship-channel a little north of the South Jetty. Number 5 is in the main ship channel, and Number 6 is near the shore of Morris Island. These points are shown on the chart herewith submitted. The main object of these observations was to obtain a basis of comparison, so that when the jetties shall have been brought up further, changes in the direction and the velocity of the currents can be studied. The observations for direction were made with a small keg attached to a measuring wire; it was submerged by partially loading it with shot, and allowed to tail off in the direction of the current. The directions at different depths were obtained by paying out more of the measured wire from time to time

until the keg reached the bottom. The velocities were taken at different depths by an electric meter. The record was made by a Morse register. The meter was suspended upon a piece of copper wire rope, to the lower end of which a heavy lead weight of about 50 pounds was attached. This rope was passed over a sheave in the end of a piece of timber about 3 inches by 4 inches, which was supported on the gunwales of the boat amidships, and overhung on the starboard side about 5 feet. This timber was lashed to the boat in order to support the weight. From the sheave the wire rope passed to a small windlass permanently attached to the cross-timber, by means of which the whole was raised and lowered. This apparatus, devised by yourself, worked very well.

A tolerably complete set of ebb-tide observations were obtained, and some valuable flood-tide observations. A full investigation of these observations has not been made, but a few interesting facts have come out in the preliminary study.

DIRECTIONS.

In the Swash Channel the general direction of flood is towards the head of Morris Island and to a point between this and Fort Sumter. The ebb tide has a direction at No. 1 from a point a little south of Fort Sumter; at No. 2 it runs more nearly from Fort Sumter; while at No. 3 it is directly from Fort Sumter and almost parallel with the south jetty. As the range of the dredge cut is the Fort Sumter light and a church spire in the city and as No. 3 is on its south limit, the location of this cut seems to be a good one, at least so far as direction is concerned. At No. 4 only a few observations were made. The flood was shown to run towards a point a little east of Fort Sumter, and the ebb in the opposite direction or obliquely across the jetty. At No. 5, in the main ship-channel, the general direction of the flood is toward the west end of Sullivan's Island, and the general direction of ebb is from Fort Moultrie. At No. 6 the flood runs toward a point between Fort Sumter and the west end of Sullivan's Island, somewhat nearer the latter, while the ebb is almost directly away from the end of Sullivan's Island. At all the stations the tide changes from north by east to south; and from south by west to north, or in the direction of the hands of a watch. In other words, when the flood tide weakens it begins to run more toward the eastward, and thus works around until it gets into the designated direction of the ebb. The ebb tide changes similarly from south by west to north.

VELOCITY.

In the Swash Channel the greatest mean velocity at ebb tide is about 2 feet per second. Greater mean velocities are generally shown at 2 and 3 than at 1; this is favorable to the maintenance of the dredge cut, which is located between the two latter. The flood velocities are also greater at Nos. 2 and 3 than at No. 1, but as I have already said, the flood observations are not so complete. For the same range of tide the maximum ebb tide is stronger than the maximum flood. At No. 5 the maximum mean velocity at ebb tide is 3.2 feet per second. The corresponding velocity at No. 6 is 2 feet per second. For the same range of tide the maximum ebb exceeds the maximum flood at No. 5, but the reverse is the case at No. 6. The maximum velocity 3.2 feet per second at No. 5 corresponds in tidal range with 2 feet per second in Swash Channel; these are the highest spring tides. The differences in ebb velocities for tides of smaller range at No. 5 and No. 6 are quite as great. The flood velocities for the same range of tide are decidedly greater at No. 5 than in the Swash Channel. At No. 6, near Morris Island, the flood tide begins running about three-quarters of an hour earlier than at No. 5, and the velocity of the flood tide at No. 6 is greater than at No. 5 in every case. The ebb tide begins running almost simultaneously at these two points. The flood tide begins running earlier at these points than in the main ship-channel. The maximum flood velocity is thus shown to be at No. 6 and the maximum ebb at No. 5. The flood tides seem to retain their strong velocities for a greater time, while they do not reach so great a maximum as the ebb. The data are not sufficient to state this positively as a general law. The flood tide is probably more diffused in area than the ebb tide, the latter seems to be more concentrated into channels. The usual survey of Swash Channel was made in April and May, 1890. The following is the result of a study of the map derived from this survey:

SWASH CHANNEL.

As compared with 1889 I find the following: The lumps of less than 9 feet on Jim Evans Shoal have moved seaward several hundred feet. They appear still more broken up and aggregate less in area. The lumps of less than 9 feet reported last year as lying between Jim Evans and the south jetty do not show this year; they have doubtless been removed by the dredging. Swash Reef is also smaller in area and is broken up into several lumps. The one of these farthest out is 400 feet sea-

ward of the farthest point of the shoal, as shown on the map of 1889. Of the outer curve the 18-foot curve shows no decided change. The 15 and 12 foot curves have both moved out toward the ocean. The inner 18 and 15 foot curves show no decided change. The area within the 12-foot curve is very decidedly smaller than in 1889. This refers to the area on which there is less than 12 feet of water at mean low tide. The difference in area is about 30 acres. The 12-foot pocket that was shown last year to the north and east of the Bell Buoy has enlarged considerably, and has also advanced seaward, the farthest point seaward being in the center line of the dredge-cut. A 12-foot channel, not very straight however, is shown, with the exception of about 600 feet, nearly opposite the outer end of the south jetty. A very good 10½-foot channel can be carried through by passing out to the south end of the bell buoy and tolerably near the south jetty, then crossing to the range of St. Michael's spire in Charleston and the south corner of Fort Sumter, and following this range out to deep water.

Some of the increased depth indicated by the 12-foot curve, must be attributed to dredging, but, as this increase in depth is not limited to the dredge cut, it would seem as though the jetties were having a more positive action than heretofore.

OTHER SURVEYS.

No surveys of the jetties have been made by sounding along their crest, nor of other channels.

CONDITION OF THE JETTIES.

No settlement is apparent in the exposed portions. The stone placed during the year on the outer 3,000 feet of the north jetty has been somewhat leveled by the action of the waves. The moderate amount of stone required to bring up that portion of the South Jetty, which crosses the deep pocket east of the Main Ship-Channel, shows that there has been no settlement here, where it has been most feared.

PROFILES.

The profiles prepared from mean soundings as described in my report last year are again submitted herewith. To them have be enadded the profiles of this year's survey prepared in the same manner. To avoid too great confusion, the profile for 1884 has been omitted. We notice that on No. 1 there is no very decided change in the depth, the minimum mean depth being about the same as last year. A decided seaward movement of material is shown however. On No. 2 there is a general increase of depth, the minimum depth has increased from 9.9 feet in 1889 to 10.3 in 1890. On No. 3 there is also a noticeable increase in depth, and the minimum has increased about .6 of a foot.

SULLIVAN'S ISLAND.

The only change in the beach is opposite Fort Moultrie, where the high-water line has moved back about 40 feet.

MORRIS ISLAND.

The portion of this island near the head, which is usually surveyed, shows very little change, such change as is shown being in the direction of increase in area within the high-water line. The high-water line on the front is nearly identical with that of 1889. This fact is somewhat remarkable, as it is the first season when such a result has been shown. The low-water line near the head has receded, making the beach somewhat narrower at this point.

MOUNT PLEASANT SHORE.

No survey of this has been made. An examination made on June 10, 1890, indicates some washing at the west end. The jetties do not show any serious deterioration, although the ends of the logs are being somewhat eaten by the teredo.

Mr. W. L. Mikell, inspector of stone, and Col. F. L. Childs, inspector of dredging, have been unremitting in attention to the duties of their positions and efficient and judicious in the discharge of these duties.

Very respectfully, your obedient servant,

JAMES P. ALLEN,
Assistant Engineer.

Capt. FREDERIC V. ABBOT,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

Arrivals and clearances of vessels and commerce at Charleston, S. C., from January 1, 1875, *to December* 31, 1889.

ARRIVED.

Year.	Coastwise.			Foreign ports.						Total.		
				American vessels.			Foreign vessels.					
	No.	Tons.	Crew.	No.	Tons.	Crew.	No.	Tons.	Crew.	No.	Tons.	Crew.
1875	504	382, 018	11, 949	38	13, 144	326	198	88, 879	2, 404	740	484, 041	14, 379
1876	471	340, 439	10, 113	44	11, 898	335	224	101, 272	2, 768	739	453, 609	13, 216
1877	400	324, 919	9, 885	32	13, 972	308	336	105, 480	2, 851	668	444, 371	13, 044
1878	396	322, 527	9, 623	44	19, 935	455	329	163, 368	3, 967	772	505, 830	14, 045
1879	383	326, 681	10, 027	39	12, 505	319	249	121, 503	3, 292	668	460, 659	13, 638
1880	441	388, 026	20, 641	38	12, 412	327	191	110, 771	2, 595	670	511, 209	13, 563
1881	412	399, 732	10, 377	34	9, 430	272	257	121, 077	3, 073	703	530, 239	13, 722
1882	410	384, 690	9, 446	35	4, 807	224	200	105, 647	2, 648	645	495, 144	12, 318
1883	345	277, 538	7, 629	26	3, 002	157	239	113, 768	2, 958	610	394, 308	10, 744
1884	425	304, 382	9, 822	21	3, 910	145	214	134, 076	3, 269	690	442, 368	13, 236
1885	375	268, 477	9, 637	15	2, 344	97	187	106, 233	2, 586	577	377, 054	12, 320
1886	901	550, 209	.....	20	3, 714	131	182	114, 507	2, 646	1, 103	668, 403	.....
1887	927	656, 949	.....	30	7, 074	199	127	67, 257	1, 607	1, 084	731, 280	.....
1888	*924	601, 771	.....	34	7, 750	252	127	72, 921	1, 779	1, 085	682, 442	.....
1889	†330	481, 718	9, 708	30	6, 985	216	136	87, 101	1, 979	496	575, 804	11, 903

* Of these, 32 vessels (tonnage, 31,035), with crews numbering 608, were foreign.
† Of these, 29 vessels (tonnage, 9,440), with crews numbering 546, were foreign.

CLEARED.

1875	461	328, 266	10, 830	57	24, 679	555	211	94, 595	2, 527	729	447, 540	13, 912
1876	431	278, 744	9, 095	60	23, 598	546	230	103, 276	2, 812	721	405, 618	12, 453
1877	335	234, 429	7, 719	35	22, 767	423	250	108, 446	2, 910	620	365, 662	11, 052
1878	266	172, 988	5, 801	45	24, 397	479	398	149, 975	3, 591	509	347, 360	14, 045
1879	287	188, 212	6, 268	34	11, 282	292	278	149, 052	3, 643	599	348, 546	10, 203
1880	296	190, 733	6, 348	45	23, 210	481	246	155, 768	3, 375	587	369, 711	10, 204
1881	268	187, 569	5, 942	32	9, 239	255	278	153, 796	3, 464	578	350, 604	9, 661
1882	147	113, 699	3, 690	40	7, 375	273	263	158, 250	3, 584	450	379, 324	7, 546
1883	98	48, 714	2, 018	27	4, 560	181	299	154, 653	3, 815	424	207. 927	6, 014
1884	212	116, 020	4, 555	31	7, 845	217	276	161, 588	3, 727	519	285, 453	8, 499
1885	191	99, 658	5, 047	24	5, 217	164	204	119, 602	2, 836	419	224, 467	8, 047
1886	890	543, 259	.....	25	5, 469	165	201	126, 943	2, 875	1, 116	675, 671	.....
1887	888	610, 646	.....	28	5, 837	189	173	115, 218	2, 546	1, 089	731, 701	.....
1888	*911	580, 468	.....	30	5, 848	211	144	96, 146	2, 105	1, 085	682, 462	.....
1889	†46	358, 596	778	25	5, 080	174	165	112, 037	2, 495	236	155, 713	3, 467

* Of these, 7 vessels (tonnage, 4,295), with crews numbering 62, were foreign.
† Of these, 4 vessels (tonnage 2,960), with crews numbering 47, were foreign.

COMMERCE.

Year.	Value of exports.	Value of imports.	Duties collected.
1875	$19, 655, 966	$680, 343	$80, 656. 00
1876	18, 088, 152	455, 562	89, 168. 00
1877	16, 917, 492	161, 237	46, 848. 00
1878	21, 167, 575	184, 127	36, 990. 00
1879	18, 693, 126	127, 981	24, 070. 00
1880	24, 939, 259	248, 158	46, 453. 98
1881	21, 927, 269	723, 049	99, 066. 23
1882	19, 907, 099	459. 970	45, 263. 33
1883	20, 144, 365	467, 648	48, 760. 69
1884	20, 833, 424	503, 504	36, 624. 76
1885	15, 157, 889	588. 191	32, 741. 68
1886	17, 410, 000	635, 000	24, 876. 00
1887	15, 288, 316	484, 063	30, 817. 00
1888	13, 006, 578	625, 770	76, 398. 00
1889	16, 080, 255	664, 696	16, 728. 82

T. B. JOHNSTON,
Collector.

Trade of Charleston, South Carolina, 1889.

IMPORTS.

Articles.	Quantity.	Tons.	Value.
Bacon	62,500,000 pounds	31,250	$3,750,000
Flour	180,000 barrels	18,000	1,000,000
Rice (foreign)	110,000 bushels	2,420	96,000
Corn	1,000,000 bushels	28,000	750,000
Hay	50,000 bales	5,000	100,000
Oats	175,000 bushels	2,650	75,000
Grist, 75,000 barrels; meal, 25,000 barrels	100,000 barrels	10,000	300,000
Sugar	100,000 barrels	15,000	1,500,000
Molasses	5,000 barrels	1,000	100,000
Salt	10,000 sacks	1,000	7,500
Sea island cotton bagging	50,000 yards	50	8,000
Bagging, 100 bales burlaps	4,000,000 yards	2,050	255,000
Jute butts	30,000 butts	6,000	270,000
Petroleum and other oils	35,000 barrels	5,950	305,000
Ice	30,000 tons	30,000	70,000
Cigars, 17,000,000; tobacco, 1,800,000 pounds		2,500	1,000,000
Groceries and dry goods (assumed)		100,000	20,000,000
Hardware (assumed)		75,000	2,000,000
Boots and shoes (assumed)		10,000	1,500,000
Crockery (assumed)		6,000	200,000
Drugs and medicines (assumed)		3,000	500,000
Granite (500,000 blocks), 8,000 tons Rubble, 60,000 tons; marble, 150 tons Brown stone, 500 tons; curbing, 150 tons Paving stone, 1,000 tons		68,800	162,600
Kainit		16,425	98,000
Brimstone		21,000	321,000
Nitrate soda		2,500	73,000
Muriate of potash		2,500	73,000
Fertilizers		1,600	10,000
Lime, brick, cement, plaster (assumed)		10,000	25,000
Manufactures (assumed)		25,000	7,000,500
		502,695	42,049,100

EXPORTS.

Cotton, upland bales	410,000 barrels	102,500	$20,500,000
Cotton, sea-island	8,000 bags	1,200	800,000
Rice	75,000 barrels	11,250	1,500,000
Rosin	150,000 barrels	25,000	300,000
Turpentine	45,000 barrels	8,000	1,000,000
Phosphate, rock	310,000 tons	310,000	2,000,000
Phosphate, ground	7,500 tons	7,500	75,000
Fertilizers	172,000 tons	172,000	3,473,500
Lumber	55,000,000 feet	1,000,000	500,000
Cotton goods, domestic and yarns	60,000 bales	10,000	3,000,000
Cotton seed	2,000 tons	2,000	36,000
Kaolin clay	17,500 casks	17,500	300,000
Strawberries	330,000 quarts	300	50,000
Potatoes	80,000 barrels	8,000	240,000
Vegetables	85,000 crates	5,000	200,000
Melons	250 car-loads	10,000	50,000
		1,690,280	34,024,500

Tonnage from Charleston, South Carolina, 1889.

	Foreign.	Domestic.
Steam-ships	58	201
Barks	84	5
Brigs	16	18
Schooners	3	416
	161	640

RECAPITULATION.

	Vessels.	Tons.
Foreign	161	113, 040
Domestic	640	623, 167
	801	736, 207

E. WILLIS.

N 2.

IMPROVEMENT OF LUMBER RIVER, NORTH CAROLINA.

REFERENCE TO PAST REPORTS.

For preliminary examination and survey see page 1102, Annual Report for 1887.

ORIGINAL CONDITION.

The river was obstructed by logs, snags, stumps, overhanging trees, and in places by sand-bars; long reaches were in fair condition. That portion of the river between Lumberton and the North Carolina line was crossed by five low bridges, without draws, and one moderately high railroad bridge near Lumberton. In South Carolina the river is crossed by two bridges without draws. The Enterprise Land and Lumber Company had a charter allowing them to control the navigation on the river, and the right to improve the river.

PLAN OF IMPROVEMENT.

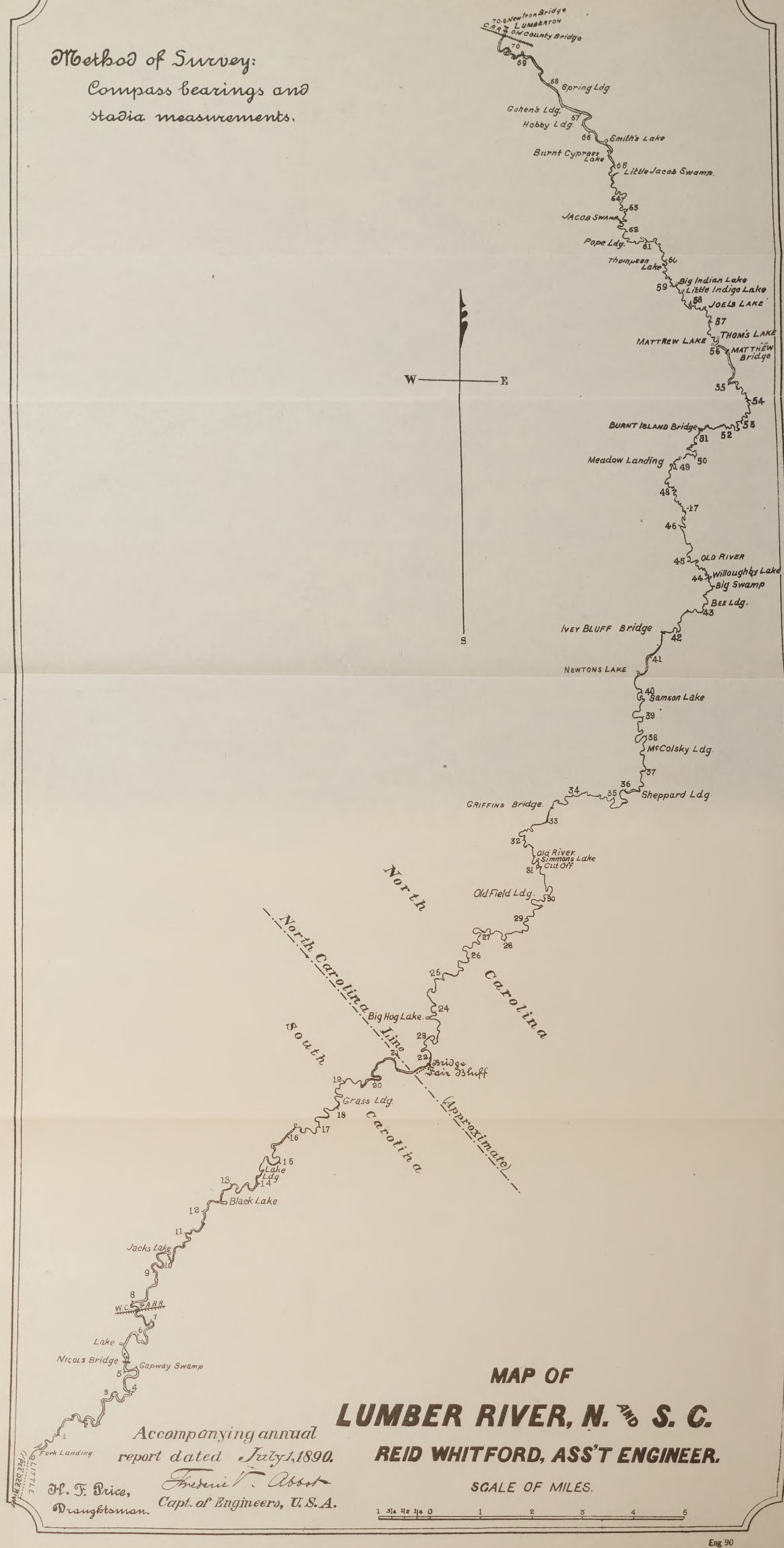
The project provides for improving the river for steam-boats from its mouth to Lumberton, a distance of 70.8 miles, by snagging and clearing the banks. The estimated cost was $35,000. No work was to be done on this river until the charter of the Enterprise Land and Lumber Company was transferred to the United States free of cost.

WORK PRIOR TO JUNE 30, 1889.

No work was done, as the charter transfer had not been completed. The parties operating the low bridges in North Carolina, were notified to put in draw-spans, but failed to do so.

WORK OF PAST YEAR.

Several papers transferring the charter rights of the Enterprise Land and Lumber Company were offered by the company, but were found to be defective in form by the Department of Justice. At the close of the fiscal year the last transfer paper, which had been made out by one of the officers of the Department of Justice, had not yet been returned with all of the signatures it required. On this account no work has been done on the river. The plant has, however, been made ready and work will begin as soon as this last transfer paper recieves the final approval of the Department of Justice. The parties operating the low


Method of Survey:
Compass bearings and
stadia measurements.
70-8 New Iron Bridge
LUMBERTON
C.R.R.
Old County Bridge
70
69
68 Spring Ldg.
Cohen's Ldg.
Hobby Ldg.
67
66 Smith's Lake
Burnt Cypress Lake
65 Little Jacob Swamp.
64
63
JACOB SWAMP
62
Pope Ldg.
61
Thompson Lake
60
59 Big Indian Lake
Little Indigo Lake
58 JOELS LAKE
57
MATTREW LAKE
THOM'S LAKE
56 MATTHEW Bridge
55
54
BURNT ISLAND Bridge
53
52
51
Meadow Landing
50
49
48
47
46
45 OLD RIVER
44 Willoughby Lake
Big Swamp
43 BEE Ldg.
IVEY BLUFF Bridge
42
41
NEWTONS LAKE
40 Samson Lake
39
38 McColsky Ldg.
37
36 Sheppard Ldg.
35
34
GRIFFINS Bridge.
33
32
Old River
Simmons Lake
Cut Off
31
Old Field Ldg.
30
29
28
27
26
25
24
23
22
Bridge
Fair Bluff
21
20
19
Grass Ldg.
18
17
16
15
Lake
Ldg.
14
13
Black Lake
12
11
Jacks Lake
10
9
8
W.C. & A.R.R.
7
6
Lake
Nicols Bridge
Gapway Swamp
5
4
3
2
1
Fork Landing
LITTLE PEEDEE R.
W
E
S
North Carolina Line
(Approximate)
North Carolina
South Carolina
MAP OF
LUMBER RIVER, N. AND S. C.
REID WHITFORD, ASS'T ENGINEER.
SCALE OF MILES.
1 3/4 1/2 1/4 0 1 2 3 4 5
Accompanying annual report dated July 1, 1890.
Frederic V. Abbot
Capt. of Engineers, U.S.A.
H. F. Price,
Draughtsman.

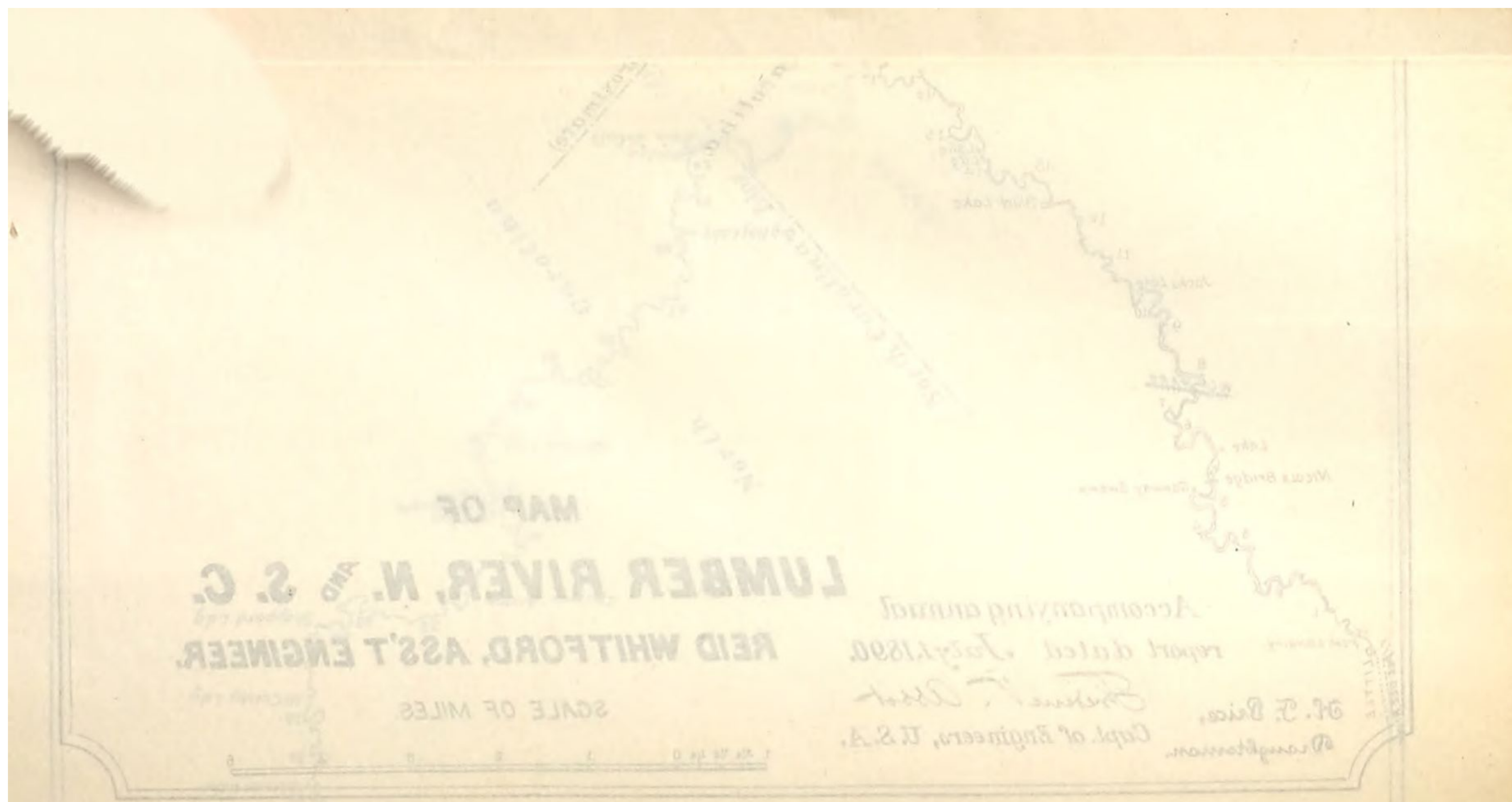
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MAP OF

LUMBER RIVER, N. & S. C.

REID WHITFORD, ASS'T ENGINEER.

SCALE OF MILES



bridges have begun to put in their draw-spans, but they were not completed at the end of the fiscal year.

My assistant engineer, Mr. Reid Whitford, deserves credit for faithful and efficient work in connection with getting up the plant, and assisting in getting up the plans for the draw-bridges.

A rapid stadia survey of the entire length of the river was made.

REMARKS.

No new transportation lines have been established on this river. With the balance of $2,884.23 on hand July 1, 1890, snagging will begin and be continued as far as the funds will admit, removing the worst obstructions first.

This river is tributary to the collection district of Georgetown, S. C.; Georgetown is its port of entry. Amount of duties collected in the calendar year of 1889, $0.00.

For this improvement the following appropriation has been made:

By act of Congress of August 11, 1888 ..... $5,000

The total expenditures, including June 30, 1890, $2,115.77.

The following papers accompany this report:

Report of Mr. Reid Whitford, assistant engineer.
Map of river.

For table of commercial statistics furnished by the collector of Georgetown, S. C., see this year's Annual Report for Waccamaw River.

Money statement.

July 1, 1889, amount available		$4,361.58
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$1,467.35	
July 1, 1890, outstanding liabilities	37.00	
		1,504.35
July 1, 1890, balance available		2,857.23
Amount appropriated by act of September 19, 1890		5,000.00
Amount available for fiscal year ending June 30, 1891		7,857.23
Amount (estimated) required for completion of existing project		25,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		25,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. REID WHITFORD, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Charleston, S. C., June 30, 1890.

CAPTAIN: I have the honor to make the following report of operations on Lumber River, North Carolina, for fiscal year ending June 30, 1890.

WORK.

Snagging was not begnn simply because the district attorney of North Carolina did not approve of the transfer paper made by the Enterprise Land and Lumber Company to the United States. A hand-hoister was completed at Lumberton; a steam-launch was built and paid for in part by this improvement's appropriation. A rapid stadia survey was made of the river from Lumberton to its mouth, a map of which is herewith sent. One water-gauge was kept during the year.

COMMERCE.

There is no commerce yet on the river, nor can there be till some of the obstructions are removed. The river flows through an exceedingly fertile and rich farming country, and many varieties of valuable timber exist along its banks. For these reasons it is but natural to expect that as soon as the river is open to navigation commerce and trade to a considerable extent will be at once developed.

The Enterprise Land and Lumber Company are about beginning extensive milling and lumber operations on the river. There is one small steamer used by them. It has been reported that the county bridges across the stream are now being supplied with proper draw-openings.

Much credit is due Mr. H. F. Price, surveyor, for excellent, very rapid, and economical survey and map work on this and the neighboring streams. I particularly thank him for his aid.

Very respectfully, your obedient servant,

REID WHITFORD,
Assistant Engineer.

Capt. FREDERICK V. ABBOT,
Corps of Engineers, U. S. A.

N 3.

IMPROVEMENT OF MINGO CREEK, SOUTH CAROLINA.

REFERENCE TO PAST REPORTS.

For preliminary examination and survey see page 1106, Annual Report for 1887.

ORIGINAL CONDITION.

The creek was much obstructed by snags and overhanging trees.

PLAN OF IMPROVEMENT.

The project provides for improving the Creek for steam-boats from its mouth to Williams Landing, and for pole-boats at high water up to the head of navigation by snagging and clearing the banks. The estimated cost is $15,000.

WORK PRIOR TO JUNE 30, 1889.

The creek was cleared from Mingo Bridge to its mouth, a distance of 17 miles. The parties operating the bridge put in a draw-span. Two hundred and ninety-five logs, snags, etc., were taken from the channel, and 1,205 overhanging trees, etc., were removed from the banks.

WORK OF PAST YEAR.

For details of work done and commercial statistics reference is made to the appended report of my assistant engineer, Mr. Reid Whitford, to whom much credit is due for careful and efficient work.

REMARKS.

With the balance of $1,068.28 on hand July 1, 1890, work will be continued under the approved project. The work already done has been of marked use. The total freights carried have increased by about

4,067 tons over last year. There have been no new transportation lines established, but the boats have made more trips.

This Creek is tributary to the collection district of Georgetown, South Carolina. Georgetown is the port of entry.

Since the existing project of improvement has been adopted, the following appropriation has been made:

By act of Congress of August 11, 1888 ..... $5,000

The total expenditures, including June 30, 1890, were $3,931.72.

The following papers accompany this report:

Report of Mr. Reid Whitford, assistant engineer, and map of the creek made from stadia survey during the past year.

Money statement.

July 1, 1889, amount available		$1,465.57
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$397.29	
July 1, 1890, outstanding liabilities	311.92	
		709.21
July 1, 1890, balance available		756.36
Amount appropriated by act of September 19, 1890		5,000.00
Amount available for fiscal year ending June 30, 1891		5,756.36
Amount (estimated) for completion of existing project		7,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		7,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

REPORT OF MR. REID WHITFORD, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Georgetown, S C., June 30, 1890.

CAPTAIN: I have the honor to make the following report of operations on Mingo Creek, South Carolina, for fiscal year ending with this date.

Work extended over the creek between 0 and 13⅛ miles from its mouth, quite thoroughly clearing a channel 40 feet wide and 4 to 6 feet deep at low water. The creek has been worked over back and forth several times from the head of navigation to its mouth, a distance of about 15 miles. During the year the following obstructions were removed from the channel and banks: 258 logs, 116 stumps, 50 large snags, 22 small snags, cords, 1,309 trees cut, 796 brush cut, cords. About seven-tenths of the money was expended on the channel and about three tenths on the banks. Each obstruction cost about 50 cents.

A stadia survey was made of the creek, a map of which is herewith forwarded. A steam-launch was built and paid for in part by this appropriation.

REMARKS.

The creek is in very good condition for navigation now, but considerable more work will have to be done before the channel is thoroughly cleared. The county drawbridge across the creek at Hemmingway's Store was completed during the year.

RECOMMENDATIONS.

It is respectfully recommended that the same character of work be carried on until a thoroughly cleared channel is completed.

COMMERCE.

The accompanying letter and statement from Messrs. F. Rhem & Sons on that subject explain themselves. The above-mentioned firm control most of the commerce on the creek and are in position to know more about the value of the commerce than any other person known to the undersigned. The commerce has been carried on by one steamer of 100 tons and numbers of pole-boats and small craft. The total freights carried have increased by about 4,067 tons over last year. There has been no new line of transportation established, but the boats have made more trips.

EMPLOYÉS.

Mr. F. A. Haddock, overseer, has shown his usual zeal and faithfulness in the discharge of his duties. All work was done by United States plant, and hired labor.

Very respectfully, your obedient servant,

REID WHITFORD,
Assistant Engineer.

Capt. FREDERIC V. ABBOT,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

RHEM'S, S. C., *May*, 1890.

DEAR SIR: We give below a statement of the commerce of Mingo Creek (River), South Carolina, from May 1, 1889, to May 1, 1890, showing the exports and imports.

The improvements have increased the commerce considerably. Steamers plying on the line that only could make two trips a week can now make three easily and get full loads. The improvements, although yet far from being completed, have increased the commerce and safety of steamers plying on this line.

While the creek below Mingo Bridge to the river needs no little improvement, the part from Mingo Bridge to Williams Landing and above needs a great deal more.

We feel satisfied that the commerce can be doubled with another small appropriation well used on this stream.

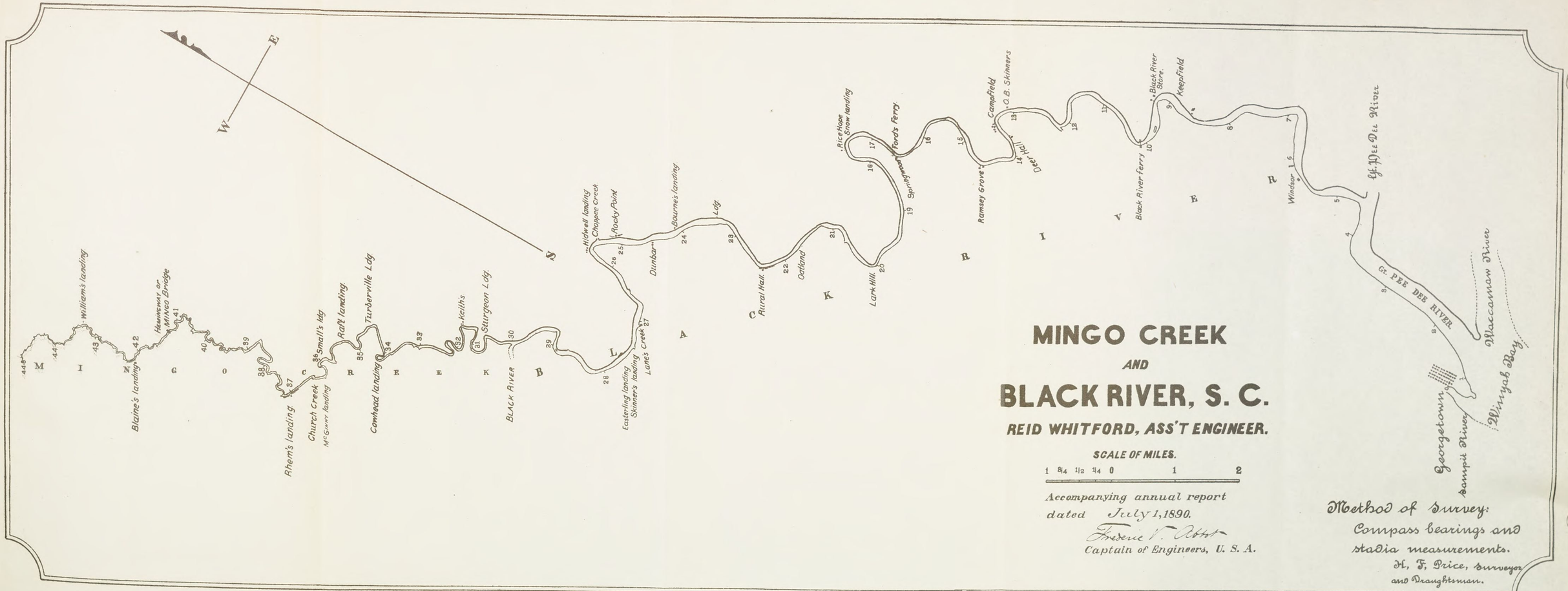
Yours, very respectfully,

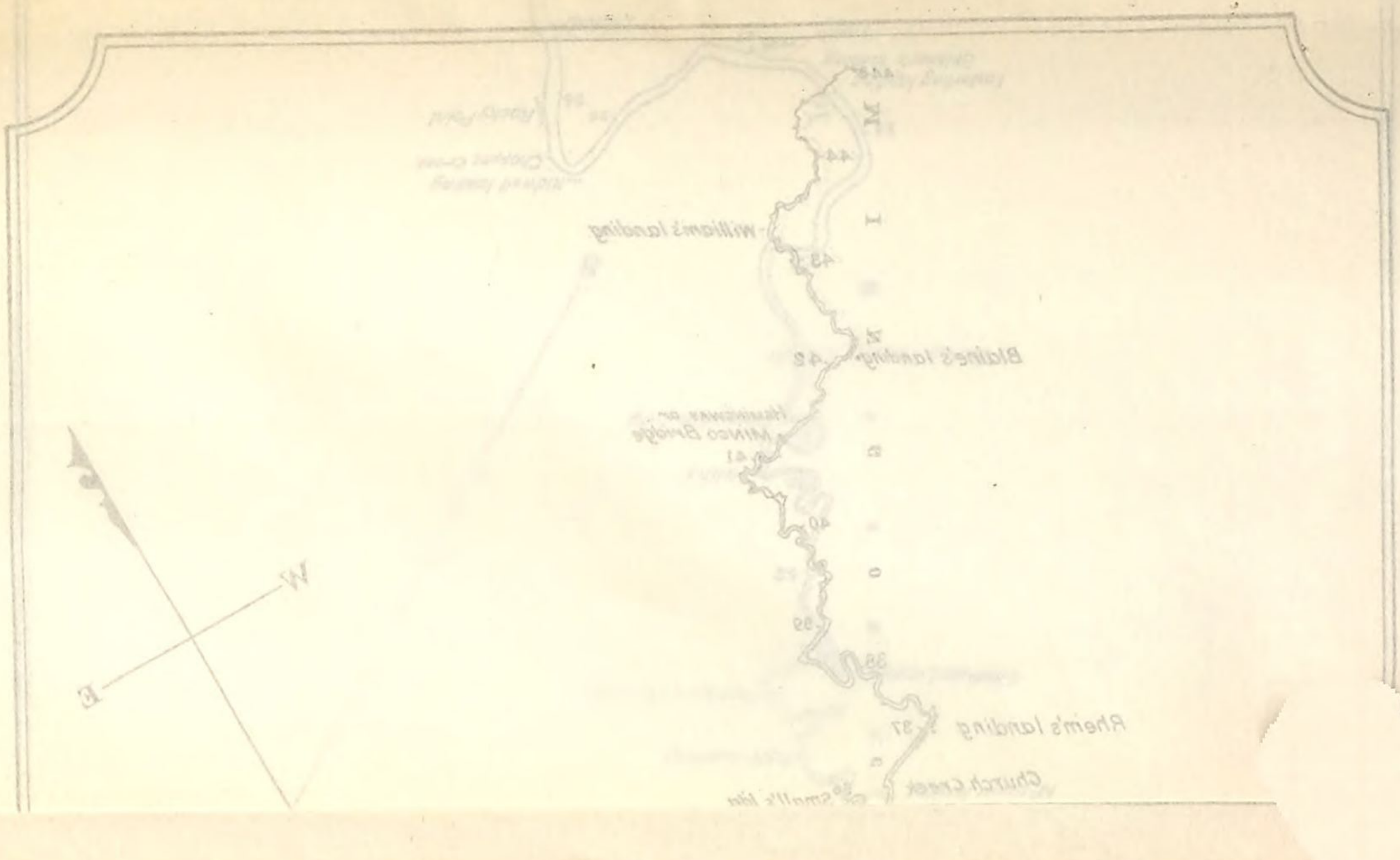
F. RHEM & SONS.

Mr. REID WHITFORD,
Assistant Engineer.

Articles.	Quantities.	Tons.	Value.
EXPORTS.			
Spirits turpentine	9,700 barrels	1,940	$194,000
Resin	60,000 barrels	12,000	135,000
Crude turpentine	5,000 barrels	1,000	20,000
Wood	5,000 cords	5,000	10,000
Staves	300,000	750	1,200
Hoop-poles	50,000	50	5,000
Cotton	4,000 bales	1,000	200,000
Shingles	650,000	32	5,200
Other produce, wool, etc		300	15,000
Lumber, cross-ties, etc		1,000	50,000
		23,072	635,400
IMPORTS.			
General merchandise brought up the creek		6,500	325,000
Total		29,572	960,400
Excess of exports			310,000

NOTE.—Tons added by myself.—Reid Whitford, assistant engineer.


N
E
W
S
MINGO CREEK
Williams landing
Blaine's landing
Hammond's or MINGO Bridge
Rhem's landing
Church Creek
McGinny landing
Small's log
Raft landing
Turberville Log
Cowhead landing
Keith's
Sturgeon Log
BLACK RIVER
Hickwell landing
Choppee Creek
Rocky Point
Easterling landing
Skinner's landing
Lane's Creek
Dunbar
Bourne's landing
Log
Rice Hope
Snow landing
Ford's Ferry
Springwood
Ramsey Grove
Campfield
O.B. Skinners
Deer Hall
Black River Ferry
Black River Store
Keepfield
Windsor
Lt. Pee Dee River
Gt. PEE DEE RIVER
Waccamaw River
Winyah Bay
Georgetown
Pampit River
MINGO CREEK
AND
BLACK RIVER, S. C.
REID WHITFORD, ASS'T ENGINEER.
SCALE OF MILES.
1 3/4 1/2 1/4 0 1 2
Accompanying annual report
dated July 1, 1890.
Frederic V. Abbot
Captain of Engineers, U. S. A.
Method of Survey:
Compass bearings and
stadia measurements.
H. F. Price, surveyor
and Draughtsman.


W
E

N 4.

IMPROVEMENT OF CLARK CREEK, SOUTH CAROLINA.

REFERENCE TO PAST REPORTS.

For preliminary examination and survey, see page 1109, Annual Report for 1887.

ORIGINAL CONDITION.

This creek is really the southern mouth of Lynch's River. Its upper end was entirely choked by a tangled mass of drift-wood and fallen trees; the lower part was fairly clear of obstructions.

PLAN OF IMPROVEMENT.

The project provides for closing the northern mouth of Lynch's River and thoroughly snagging Clark Creek. The estimated cost is $7,500.

WORK PRIOR TO JUNE 30, 1889.

Work was prevented by continuous high water.

WORK OF PAST YEAR.

The lower 3 miles of the creek was quite thoroughly cleared of obstructions to a width and depth of 40 feet and 3 feet at low water. The last three-fourths of a mile nearest to Lynch's River was so much obstructed and the appropriation was so small that it was impossible to really improve it with the money on hand. For about the last 600 feet a passage 25 feet wide was all that could be made with the funds available, and this can only be used during high water. At that time timber rafts can get through, which was not possible before. A stadia survey of the creek was made.

REMARKS.

There is no commerce on this creek, as there can be no navigation until it is clear, and the funds available were insufficient to put the improvement all the way through. The balance ($30.07) on hand July 1, 1890, is too small to admit of further work. If further funds are provided the creek will be cleared as far as possible of channel obstructions.

This creek is tributary to the collection district of Georgetown, South Carolina; Georgetown is the port of entry.

For this work the following appropriation has been made:

By act of Congress of August 11, 1888..... $2,500

The total expenditures, including June 30, 1890, have been $2,463.93.

The following papers accompany this report:

Report of Mr. Reid Whitford, assistant engineer, to whom much credit is due for careful and efficient work.

Map of the creek from stadia survey made during the year.

For table of commercial statistics furnished by the collector at Georgetown, S. C., see this year's Annual Report for Waccamaw River.

Money statement.

July 1, 1889, amount available		$1,932.42
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$1,896.35	
July 1, 1890, outstanding liabilities	6.00	
		1,902.35
July 1, 1890, balance available		30.07
Amount appropriated by act of September 19, 1890		2,500.00
Amount available for fiscal year ending June 30, 1891		2,530.07
Amount (estimated) required for completion of existing project		2,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		2,500.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

REPORT OF MR. REID WHITFORD, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Georgetown, S. C., June 30, 1890.

CAPTAIN: I have the honor to make the following report of operations on Clark Creek, South Carolina, for fiscal year of 1889-'90:

Work was begun with Mr. Thomas W. Daggett's hired hoister and crew at the mouth of the creek, 2 miles above Smith's Mills, on October 3, 1889, and continued until November 14 following, when Lynch's River, distant 6¾ miles was reached, and the appropriation ($2,500) exhausted.

The first 3 miles was quite thoroughly cleared of obstructions to width and depth of 40 and 3 feet at low water. The remaining three-quarters of a mile was roughly worked over; the last 590 feet next to Lynch's River being solidly packed with logs the entire width of the stream, only a passage of 25 feet could be made through this place, and can only be used during the flush-water period of the creek when timber rafts can get through. These obstructions were removed: seven hundred and ninety-nine logs, 11 stumps, 252 large snags, 12 cords of small snags, 195 trees, and 35 cords of brush. About one-tenth of the total amount was used on the banks and nine-tenths on the channel. The cost of removing obstructions from the channel was about $1.55 apiece and the banks 96 cents. A steam-launch was built and partly paid for by this improvement. One water-gauge at Effingham was kept during the year. The creek was rapidly surveyed by compass bearings and stadia measurements, a map of which is herewith sent.

REMARKS.

The creek when once fairly opened will be of great benefit to the people living on Lynch's River. They will then have an outlet into the Great Pee Dee River. There is much valuable timber and fertile, well-cultivated land along Clark Creek and Lynch's River.

RECOMMENDATIONS.

It is respectfully recommended that th ework of snagging and clearing banks be continued until an unobstructed channel-way be provided. In addition to this a timber dam be built across Lynch's River below the mouth of Clark Creek, to keep out the drift which enters into Lynch's River from Great Pee Dee during freshets.

COMMERCE.

There is no commerce on the creek yet, nor can there be until the channel is more thoroughly cleared. The last appropriation was so small that not much real good to commerce could be accomplished.

EMPLOYÉS.

I am indebted to Mr. C. J. Banta, time-keeper, for the efficiency and accuracy with which he performed his duties. Mr. Daggett showed the usual zeal and energy which characterizes him in all he undertakes.

Very respectfully, your obedient servant,

REID WHITFORD,
Assistant Engineer.

Capt. FREDERIC V. ABBOT,
Corps of Engineers, U. S. A.

CLARK'S CREEK, S. C.

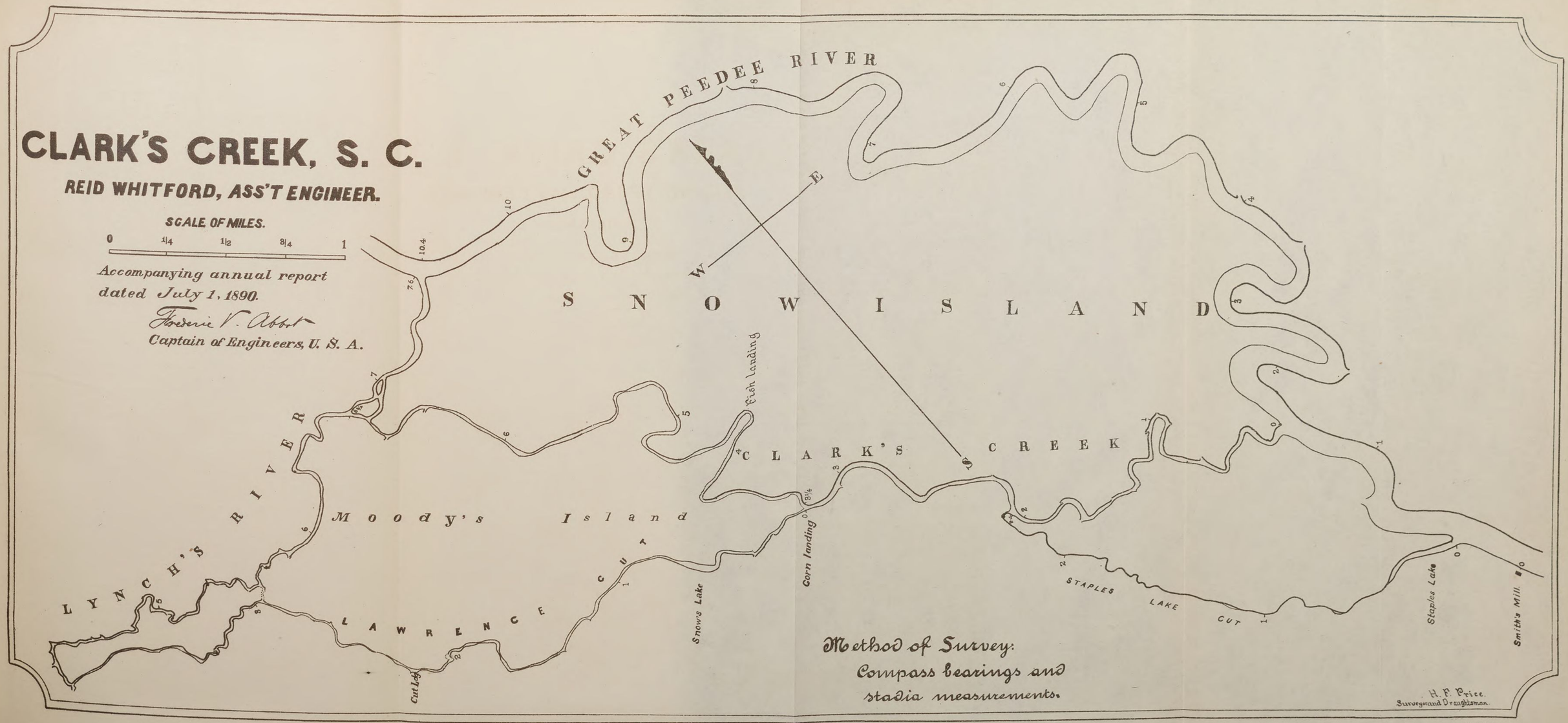
REID WHITFORD, ASS'T ENGINEER.

SCALE OF MILES.

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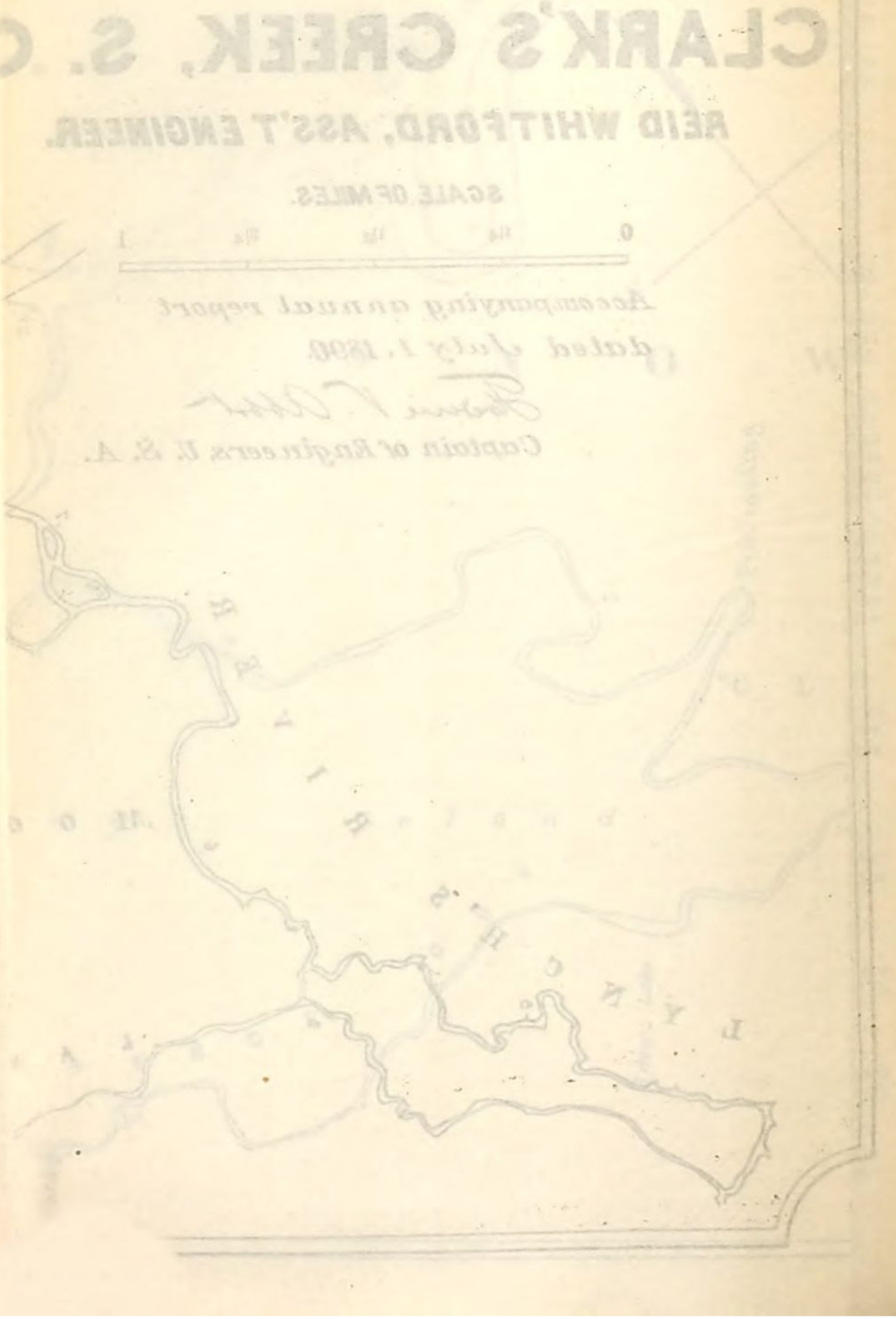
Accompanying annual report dated July 1, 1890.

Frederic V. Abbot
Captain of Engineers, U. S. A.



Method of Survey:
Compass bearings and stadia measurements.

H. F. Price.
Surveyor and Draughtsman.



N 5.

IMPROVEMENT OF ASHLEY RIVER, SOUTH CAROLINA.

REFERENCE TO PAST REPORTS.

For project of improvement, see Appendix S 8, of the Annual Report of the Chief of Engineers for 1873.

PLAN OF IMPROVEMENT.

A depth of from 10 to 11 feet at two shoals was to be secured by dredging. The cost of the work was estimated at $5,000. It has been completed for less; 22,124 cubic yards of material having been dredged and removed.

WORK OF PAST YEAR.

No work was done. With the approval of the Department the sum of $1,000, appropriated by the act approved August 5, 1886, is held for the present to be expended when necessary in dredging at any point on the river which may shoal to a less depth at low water than 10 or 11 feet.

REMARKS.

The reaches already improved are in a fairly satisfactory condition, no shoaling of consequence having occurred since they originally were dredged.

Appropriations made to date exceed the estimated cost of improvement about $500, but the expenses thus far incurred are less than the estimate. Although the improvement has been satisfactorily maintained, it is probable that further dredging will have to be resorted to at intervals.

On February 19 a complaint was made by Mr. H. S. Cordes, general manager of the South Carolina Steam-boat Company, and a number of other steam-boat owners, and masters of steam-boats and tug-boats, against the new bridge across Ashley River, near Charleston. The matter was reported to the Department, and, in accordance with instructions received, a public hearing was given at which all parties interested in the bridge and in the navigation of the river were afforded the opportunity to express their views. A complete copy of the proceedings was forwarded to the Chief of Engineers for his action, and the matter was by him referred to a Board of Engineer Officers, consisting of Capt. W. H. Bixby, Corps of Engineers; Capt. Frederic V. Abbot, Corps of Engineers; and First Lieut. O. M. Carter, Corps of Engineers; the Board being constituted by Special Orders No. 22, Headquarters Corps of Engineers, U. S. Army, Washington, D. C., April 25, 1890. The Board met at noon of May 16, 1890; heard all evidence presented before it, and ordered certain maps and surveys made. These maps have been completed, and are now before the Board. The making of these surveys and the study of the results obtained from them required so much time that by the end of the fiscal year the Board was unable to submit its final report. The Board established the fact that, as now constructed, the bridge is an obstruction to navigation, as defined by section 9 of the river and harbor act of August 11, 1888; but no decision has been officially rendered as to what changes the bridge company will be required to make.

COMMERCE.

Appended to this report will be found a letter from Mr. Edward Willis, of Charleston, S. C., giving a full statement of the annual commerce on Ashley River during the year ending December 31, 1889.

The balance on hand on July 1, 1890, $846, will be held to be used in case shoaling occurs during the coming fiscal year.

No new transportation lines have been established during the year.

This work is located in the collection district of Charleston, S. C. Charleston is the nearest port of entry. Amount of duties collected during the calendar year 1889, $16,728.82.

Since the plan of improvement was adopted the following appropriations have been made:

By act of Congress approved—	
June 14, 1880	$1,000
March 3, 1881	1,500
July 5, 1884	2,000
August 5, 1886	1,000
Total	5,500

Total expenditures to June 30, 1890, were $4,654.

The following papers accompany this report:

Statistical letter of Mr. Edward Willis, Charleston, S. C.

Money statement.

July 1, 1889, amount available	$1,005.09
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	159.09
July 1, 1890, balance available	846.00

COMMERCIAL STATISTICS.

[Furnished by Mr. E. Willis.]

This great tributary to the phosphate trade and supplies of materials used in the manufacture of commercial manures. The stream is greatly benefited by the judicious Government expenditure. Now steamers ply with ease, where it was formerly difficult for light-draught sailing vessels; new manufactories being built, and the old ones enlarged, and the whole trade prosperous and increasing steadily each year.

Articles.	1888.	1889.
Tons phosphate rock (1888, 190,000 tons; 1889, 210,000 tons)	$1,045,000	$1,200,000
Sulphur, kainit, blood, potash	750,000	800,000
Lumber, shingles, ties (25,000 tons)	30,000	35,000
Miscellaneous (1,000 tons)	25,000	30,000
	1,850,000	2,965,000

N 6.

IMPROVEMENT OF EDISTO RIVER, SOUTH CAROLINA.

REFERENCE TO PAST REPORTS.

For preliminary examination see Appendix J 15 of the Annual Report of the Chief of Engineers for 1881; for modified project see Annual Report Chief of Engineers for 1889, page 1168.

ORIGINAL CONDITION.

The river was choked with snags and had many half-formed natural cut-offs.

PLAN OF IMPROVEMENT.

The plan provides for snagging, etc., to give easy navigation for rafts and flat-boats from Guignard's Landing to the mouth of the river, a distance of about 260 miles. The estimated cost was $33,385.

WORK PRIOR TO JUNE 30, 1889.

From the mouth of the river to the South Carolina Railway Bridge, a distance by river of 180 miles, 19,510 logs, snags, and overhanging trees had been removed. Numerous outlets into the swamp and several incipient cut-offs known as sucks had been closed and one large suck had been opened and made the main channel of the river. The result was about 180 miles of river fairly cleared for raft navigation.

WORK OF PAST YEAR.

Snagging has been continued by hired labor. About two-thirds of the work was done on those portions of the river formerly worked over, the rest on the 47 miles of river next above the South Carolina Railway Bridge, which marked the upper limit of work under previous appropriations. For details of work done reference is made to the report of my assistant engineer, Mr. James P. Allen, to whom much credit is due for faithful and efficient work.

REMARKS.

No new transportation lines have been established during the year.

With the balance of $336.50 on hand July 1, 1890, the United States plant will be cared for.

This improvement is located in the collection district of Charleston, S. C. Charleston on the north and Beaufort on the south are the nearest ports of entry.

Duties on imports collected in 1889 at the custom-house in Charleston, $16,728.82, and Beaufort, S. C., $160.

Since the present project of improvement was adopted the following appropriations have been made:

By act of Congress passed August 2, 1882	$8,000
By act of Congress approved July 5, 1884	5,000
By act of Congress approved August 5, 1886	3,000
By act of Congress of August 11, 1888	5,000
Total	21,000

The total expenditures to June 30, 1890, $20,663.50.

The following papers accompany this report:

Report of Mr. James P. Allen, assistant engineer.
Statistic letter from Mr. J. D. Ackerman.

For table of commercial statistics furnished by the collector of Beaufort, S. C., see this year's Annual Report for Salkiehatchie River, and for table of commercial statistics furnished by the collector of the port of Charleston, S. C., see Annual Report for this year for Charleston Harbor, South Carolina.

Money statement.

July 1, 1889, amount available		$2,709.46
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$2,372.96	
July 1, 1890, outstanding liabilities	2.00	
		2,374.96
July 1, 1890, balance available		334.50
Amount appropriated by act of September 19, 1890		5,000.00
Amount available for fiscal year ending June 30, 1891		5,334.50
Amount (estimated) required for completion of existing project		7,385.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		7,385.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

REPORT OF MR. JAMES P. ALLEN, ASSISTANT ENGINEER

UNITED STATES ENGINEER OFFICE,
Charleston, S. C., June 30, 1890.

CAPTAIN: I have the honor to submit the following report upon the improvement of Edisto River, South Carolina.

Work on this river, which was discontinued about the end of June, 1889, on account of high water, could not be resumed for the same cause until October, 1889. At that time work on the lower river below the South Carolina Railway Bridge was resumed. It consisted of removing obstructions, in repairs to the closure of McLeod's Suck, and the closing of four of the sucks, and some work at Taff Rumph Suck. Work was done at this time between Lisston Old River and Taff Rumph Suck, between Norman's Landing and Parker's Ferry, and at McLeod's Suck. Five hundred and forty-four trees and 110½ cords of brush were cut from the banks; 399 logs, 66 stumps, 330 large snags and 34¾ cords of small snags were removed from the bed, and 4 sucks were closed on about 22 miles of river, within the limits already designated, at a total cost of $961.57. About seven-tenths of the money was expended on the work in the water and three-tenths on the banks. Each obstruction cost about 55 cents. It was expected at this time to expend the balance of the appropriation on that portion of the river between Hollman's Bridge and the South Carolina Railway Bridge, where no work had ever been done before by the United States. The river being too high, however, work was discontinued, and as the continuance of high water was to be expected in winter, it was not resumed until March, 1890. At that time two parties were set at work, one at Hollman's Bridge and the other at Cannon's Bridge, each working down stream and removing only the most serious obstructions, as the funds on hand were not sufficient to clear this portion of the river thoroughly. These parties continued working until near the end of April, at which time they had very nearly exhausted the appropriation. At this time, also, some work was done at Taff Rumph Suck. Eight hundred and eighty-one trees and 178 cords of brush were cut from the banks, and 606 logs, 190 stumps, 305 large snags, and 72 cords of small snags were removed from the channel, and one suck was closed on about 47 miles of river, at a total cost of about $1,376. About seven-tenths of the money has been expended on the work in the water and three-tenths on the banks. Each obstruction cost about 60 cents.

The aggregate work for the year is as follows:

From the banks 1,425 trees and 288½ cords of brush have been cut; from the channel, 1,005 logs, 256 stumps, 635 snags, and 106¾ cords of small snags have been removed; five sucks have been closed on about 69 miles of the river.

An examination of the upper river in October, 1889, before work began, shows this part to be in very bad condition. No examination has been made since the work stopped. An examination of the river from the South Carolina Railway Bridge to the Charleston and Savannah Railroad Bridge at Jacksonboro in April, 1890, shows this portion, with the exception of Taff Rumph Suck, to be in very good condition for rafting purposes.

Mr. J. D. Ackerman and Mr. B. G. Willis have filled the positions of overseers on this work creditably.

Very respectfully, your obedient servant,

JAMES P. ALLEN,
Assistant Engineer.

Capt. FREDERIC V. ABBOT,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

COTTAGEVILLE, S. C., *May* 27, 1890.

DEAR SIR: I beg leave herewith to send the following report of commerce passing over the Edisto River for the year 1889:

Articles.	Unit of quantity.	1887.		1888.		1889.	
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Sawed lumber....	B. M. feet ...	30, 000, 000	$240, 000. 00	32, 000, 000	$256, 000. 00	32, 500, 000	$260, 000
Hewn timber	Feet	15, 000, 000	90, 000. 00	15, 000, 000	90, 000. 00	18, 000, 000	126, 000
Round timber	Linear feet .	1, 500, 000	75, 000. 00	2, 000, 000	100, 000. 00	1, 500, 000	75, 000
Cross-ties	Feet	38, 000	3, 500. 00	60, 000	4, 800. 00	2, 000, 000	160, 000
Miscellaneous, cord-wood, etc..	.....	.....	10, 000. 00	.....	8, 000. 00	.....	6, 000
Rice.....	Bushels.....	124, 982	149, 970. 40	130, 114	156, 136. 68	128, 340	154, 008
Total.....	.....	.....	568, 478. 40	.....	614, 936. 68	.....	781, 008

	Tons.
Timber, etc., 1889	122, 400
Rice, 1889	2, 053
Total	144, 453

Respectfully submitted.
Your obedient servant,

J. P. ACKERMAN.

Capt. F. V. ABBOT,
U. S. Engineer Office.

N 7.

IMPROVEMENT OF SALKAHATCHIE RIVER, SOUTH CAROLINA.

REFERENCE TO PAST REPORTS.

For the project of improvement see Appendix J 16, Annual Report Chief of Engineers for 1881.

ORIGINAL CONDITION.

The river was choked with logs and snags, and in some places was divided into many small branches by numerous low-lying lands.

PLAN OF IMPROVEMENT.

The project provides for clearing the channel for rafts and flat-boats, from a point 5 miles above Toby's Bluff to Hickory Hill, 46 miles above the river mouth, comprising a total length of river of 77 miles. The estimated cost was $18,000.

WORK PRIOR TO JUNE 30, 1889.

Twelve thousand three hundred and ten snags, stumps, logs, and overhanging trees were taken from the channel and banks. Over 138 outlets were closed, 2 shoals or islands removed, 27 mud and sand points were cut off, and the banks were trimmed in numerous places. One dam was built to remove a local shoal, 1 suck was opened, providing thereby a better channel, and one bad suck was closed.

WORK OF PAST YEAR.

All work done during the past year was done by plant owned by the United States, and hired labor. The work done consisted mainly in closing outlets and in providing a low-water channel between the Forks and the Charleston and Savannah Railroad Bridge. Those closed at Du Bois Sand Drag cost about $37 apiece; those at the Weekly Sand Drag about $30 apiece. The average cost of obstructions removed from the channel was about $1.75 apiece.

For details of work done, reference is made to the report of my assistant engineer, Mr. James P. Allen, to whom much credit is due for zealous and efficient work.

REMARKS.

No new transportation lines have been established on the river during the year. Those using the river report benefit from this last year's work.

With the balance of $245.15 on hand July 1, 1890, the Government plant will be cared for.

This river is in the collection district of Charleston, S. C. Beaufort is the nearest port of entry. Amount of duties collected in the calendar year 1889, $160.

Since the existing project of improvement has been adopted the following appropriations have been made:

By act of Congress passed August 2, 1882	$5,000
By act of Congress approved July 5, 1884	3,000
By act of Congress approved August 5, 1886	2,000
By act of Congress of August 11, 1888	3,000
Total	13,000

The total expenditures to June 30, 1890, were $12,754.85.

A table of commercial statistics, furnished by the collector of the port of Beaufort, S. C., is transmitted herewith; also a letter of statistics furnished by Mr. W. D. Niles, and report of Mr. James E. Allen, assistant engineer.

Money statement.

July 1, 1889, amount available		$1,472.48
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$1,227.33	
July 1, 1890, outstanding liabilities	2.00	
		1,229.33
July 1, 1890, balance available		243.15
Amount appropriated by act of September 19, 1890		5,000.00
Amount available for fiscal year ending June 30, 1891		5,243.15

REPORT OF MR. JAMES P. ALLEN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Charleston, S. C., June 30, 1890.

CAPTAIN: I have the honor to submit the following report upon the improvement of Salkahatchie River, South Carolina, during the fiscal year ending June 30, 1890:

Work was discontinued about the end of June, 1889, on account of high water, and was not resumed until October, 1889. During the month of October 10 outlets were closed at the Du Bois Sand Drag, 3 old closures were repaired, and 18 had additional work done on them. This additional work consisted in protecting the ends by driv-

ing stakes at these points in order to prevent the water from cutting around. Besides this, some work was done for 4 miles above Toby's Bluff, consisting of the removal of recently fallen trees, etc.; 18 trees and 1¼ cords of brush were cut from the banks, and 9 logs and 1 stump were removed from the channel. The total cost of this work, together with the closures of outlets already mentioned, was $553.85. Estimating the small number of trees, etc., that were removed at a cost of $2 each, which was the sum reported last year, we have $495.35 as the amount spent upon 31 outlets. Of these, 21 were repaired or had additional work done on them, at a cost of about $6 each. The 10 new outlets, consequently, cost $36.93 each. An inspection of this work, made while it was in progress, showed that it was being economically and judiciously managed by Mr. W. D. Niles, overseer.

Work was again discontinued at the end of October, on account of high water, and was not resumed until March, 1890.

During March, April, and May 5 outlets were closed at the Weekly Sand Drag and 2 had additional work or repairs put upon them; 19 trees and 2⅓ cords of brush were cut from the banks, and 133 logs, 103 stumps, 31 large snags, and 3¾ cords of small snags were removed from the bed, mainly to secure a low-water channel of from 15 to 20 feet width, so that timber can be run out at a lower stage than heretofore. The total cost of this work is $671.61, distributed as follows: About $30 each for the 5 new closures and $6 each for the 2 old closures repaired, leaving $509.61. This gives an average cost of $1.75 for obstructions removed. Less than one-tenth of this work was done upon the banks.

Very respectfully, your obedient servant,

JAMES P. ALLEN,
Assistant Engineer.

Capt. FREDERIC V. ABBOT,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

Arrival and clearances of vessels and commerce at Beaufort, South Carolina, from January 1, 1888, *to December* 31, 1888.

ARRIVED.

Year.	Coastwise.			Foreign ports.						Total.		
				American vessels.			Foreign vessels.					
	No.	Tons.	Crew.	No.	Tons.	Crew.	No.	Tons.	Crew.	No.	Tons.	Crew.
1888.....	103	121, 207	2, 630	3	1, 093	26	30	21, 785	422	136	144, 085	3, 078
1889.....	98	128, 834	2, 728	2	1, 461	19	58	54, 464	1, 096	158	230, 193	3, 853

CLEARED.

1888.....	57	63, 287	1, 566	3	1, 465	33	78	85, 523	1, 561	138	150, 275	3, 160
1889.....	57	73, 744	1, 872	....	.....	.....	98	99, 898	1, 944	155	173, 642	3, 816

Commerce.

Year.	Value of exports.	Value of imports.	Duties collected.
1888	$850, 393. 00	$65, 645. 36	$17. 00
1889	1, 083, 085. 00	24, 266. 00	160. 00

ROBERT SMALLS,
Collector.

SALKAHATCHIE RIVER, S. C., *June* 10, 1890.

DEAR SIR: In reply to yours of April 8, I hereby submit the following report of the commerce passing over the Salkahatchie River, South Carolina, for the year 1889:

Articles.	Unit of quantity.	1887.		1888.		1889.	
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Lumber, sawed	Feet, B. M	4,450,000	$32,050	3,000,000	$30,000	3,500,000	$31,500
Timber, hewn	Feet, B. M	.....	.....	400,000	2,000	160,000	800
Cross-ties	.....	41,000	13,120	40,000	12,000	17,000	4,590
Rice	Bushels	200,000	250,000	170,000	200,000	175,000	218,750
Naval stores	Casks	2,125	38,875	2,000	36,000	2,000	34,000
Rosin	Barrels	9,798	15,000	8,000	16,000	8,000	12,000
Miscellaneous: Staves, shingles, merchandise, etc.	.....	.....	.....	.....	4,000	.....	10,000
Total	.....	.....	342,045	.....	300,000	.....	311,640

	Tons.
Lumber	9,612
Rice	3,850
Naval stores	2,025
Miscellaneous articles	513
Total for year 1889	16,000

W. D. NILES.

Capt. F. V. ABBOT,
Corps of Engineers, U. S. A.

N 8.

IMPROVEMENT OF LITTLE PEE DEE RIVER, SOUTH CAROLINA.

REFERENCE TO PAST REPORTS.

For preliminary examination and survey, see page 1111, Annual Report for 1887.

ORIGINAL CONDITION.

The river was much obstructed by snags and overhanging trees, and in places was divided into several branches, in neither of which there was a good channel, and in part by ten bridges without draws.

PLAN OF IMPROVEMENT.

The project provides for snagging and clearing the river and closing unnecessary branches so as to throw the water into one channel. Steam-boat navigation is to be provided up to the mouth of Lumber River, pole-boat navigation thence to Little Rock. The estimated cost is $50,000.

WORK PRIOR TO JUNE 30, 1889.

Eight hundred and eighty-six obstructions, consisting of logs, snags, etc., were removed from the channel, and 1,867 overhanging trees were removed from the banks.

WORK OF PAST YEAR.

The whole river from Little Rock to its mouth, a distance of about 113 miles, has been roughly worked over, clearing the channel of worst obstructions for pole boats down to the mouth of Lumber River, and for steam-boats below that point. The work has been done entirely by hired labor and plant owned by the United States.

For details of work done, reference is made to the report of my assistant engineer, Mr. Reid Whitford, to whom much credit is due for faithful and efficient work.

A rapid survey of the entire length of the river was made.

REMARKS.

No new transportation line has been established.

The river has been much benefited, but a great deal of work remains to be done. With the balance of $417.22 on hand July 1, 1890, snagging will be continued, removing the worst obstructions.

This river is tributary to the collection district of Georgetown, S. C.; Georgetown is the port of entry.

For this improvement the following appropriation has been made:

By act of Congress of August 11, 1888 ..... $5,000

The total expenditures, including June 30, 1890, were $4,582.78.

The following papers accompany this report:

Report of Mr. Reid Whitford, assistant engineer.
Map of river.
Letter from J. E. Dusenbury & Co., giving statistics.
Letter from S. J. Hennery.

For table of commercial statistics furnished by collector of Georgetown, S. C., see this year's annual report for Waccamaw River.

Money statement.

July 1, 1889, amount available		$1,544.85
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$1,127.63	
July 1, 1890, outstanding liabilities	109.82	
		1,237.45
July 1, 1890, balance available		307.40
Amount appropriated by act of September 19, 1890		5,000.00
Amount available for fiscal year ending June 30, 1891		5,307.40
Amount (estimated) required for completion of existing project		40,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		20,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

REPORT OF MR. REID WHITFORD, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Georgetown, S. C., June 30, 1890.

CAPTAIN: I have the honor to make the following report of operations upon Little Pee Dee River, South Carolina, for fiscal year ending with this date:

The river was roughly cleared of obstructions for pole-boat navigation between the town of Little Rock, at the head of navigation, and the mouth of Lumber River, a

length of 47.7 miles, as the original project required, and work was carried on also between points 15 and 65 miles above the mouth of the river for steam-boat navigation, roughly clearing the channel. The whole stream has been worked over a distance of 112.7 miles, roughly clearing the channel of obstructions for steam-boat and pole-boat navigation.

The following work has been done in this fiscal year: Six hundred and eighty-seven logs, 147 stumps, 642 large snags, 5 small snags, cords, 1,022 trees cut, 221 brush cords removed from the water and banks. About six-tenths of the money has been expended on the work in the water, and four-tenths on the banks. Each obstruction cost about 64 cents. A water-gauge on the river has been kept during the year. A steam-launch was built and paid for in part by this appropriation. A stadia survey was made of the river from Little Rock to its mouth, a map of which is herewith forwarded.

The river is now in a fair condition for navigation by steam-boats from its mouth to Lumber River, and for pole-boats from there to Little Rock. A great deal of snagging work is still left to be done before the river can be said to have been thoroughly cleared of these obstructions.

RECOMMENDATIONS.

It is respectfully recommended that the same character of work be carried on until a thoroughly cleared channel is completed.

COMMERCE.

The accompanying letters from Messrs. J. E. Dusenbury & Co., and S. J. Hennery on the above subject explain themselves. The accompanying commercial statistics are consolidated from statements furnished by these gentlemen; they are as correct as can be obtained. The total amount of freights carried have increased by about 261 tons over last year. There have been no new transportation lines established.

EMPLOYÉS.

Mr. B. T. Daggett, overseer, and Mr. J. C. Tamplet, time-keeper, have displayed marked efficiency in discharge of their duties. All work was done by United States plant and hired labor.

Very respectfully, your obedient servant,

REID WHITFORD,
Assistant Engineer.

Capt. FREDERIC V. ABBOT,
Corps of Engineers, U. S. A.

LETTERS FROM MESSRS. J. E. DUSENBURY & CO., AND MR. S. J. HENNERY.

PORT HARRELSON, S. C., *April* 23, 1890.

DEAR SIR: We herewith inclose statement of shipments both from and to this place the past year. Also statement of business done on Little Pee Dee River, which although it is partly estimated, yet it is about correct.

We think the work that has been done on the Little Pee Dee River has given good results. Steamers have been run on that river as high up as Gallivant's Ferry on a full river, and the channel has been so improved that flat-boats are now being run at a much lower stage of the river than formerly.

The completion of the proposed work will greatly increase the exports and imports in that section and would tend to develop a large section of country, which is at the present time entirely without necessary transportation facilities.

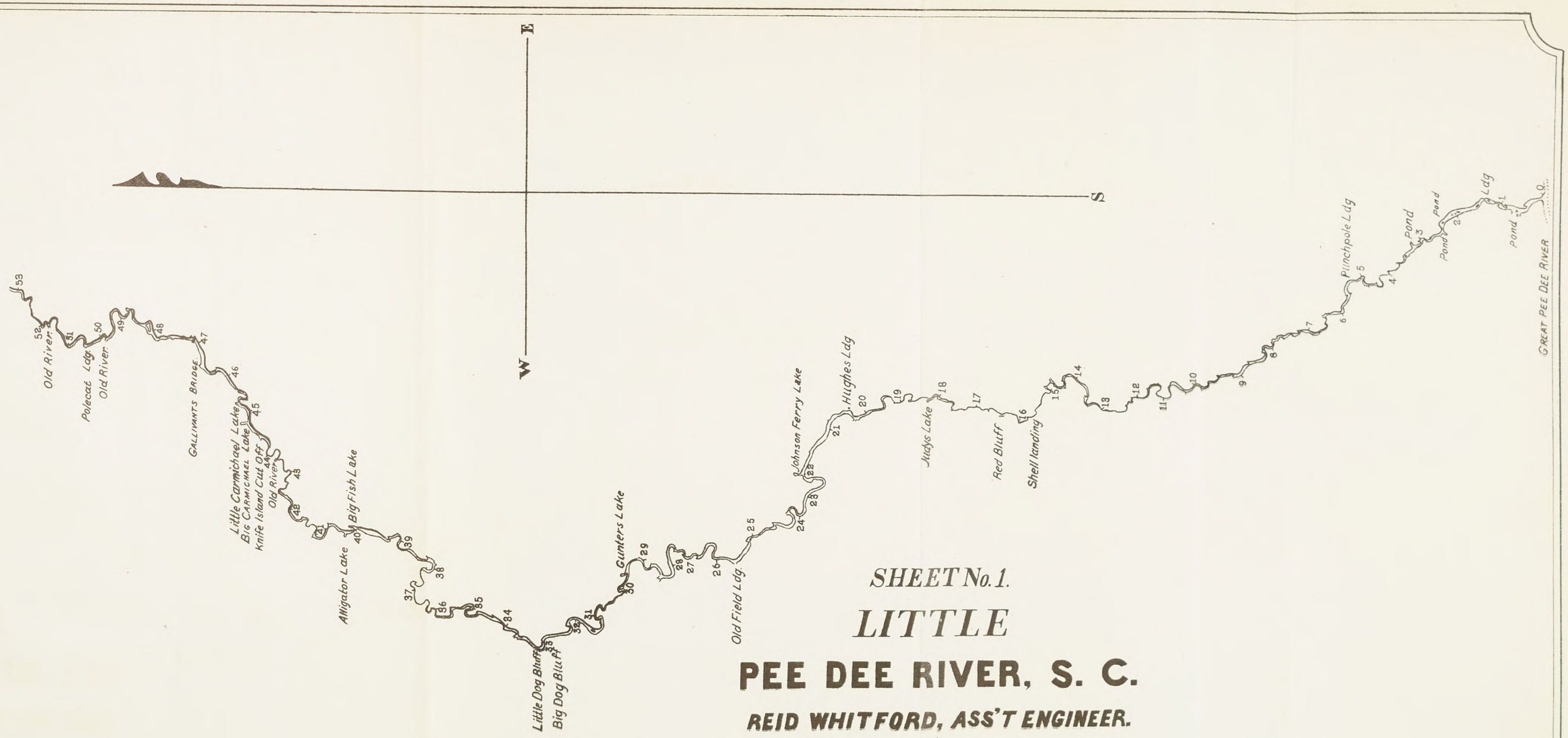
Very truly, yours,

J. E. DUNSENBURY & Co.

Mr. REID WHITFORD,
Georgetown, S. C.

PORT HARRELSON, S. C., *April* 23, 1890.

DEAR SIR: We find the work done on the Little Pee Dee River has given good results. We are now able to use steam-boats on a full river where steam-boats were never able to go before the work was done. We can now use flat-boats at a much



SHEET No. 1.

LITTLE

PEE DEE RIVER, S. C.

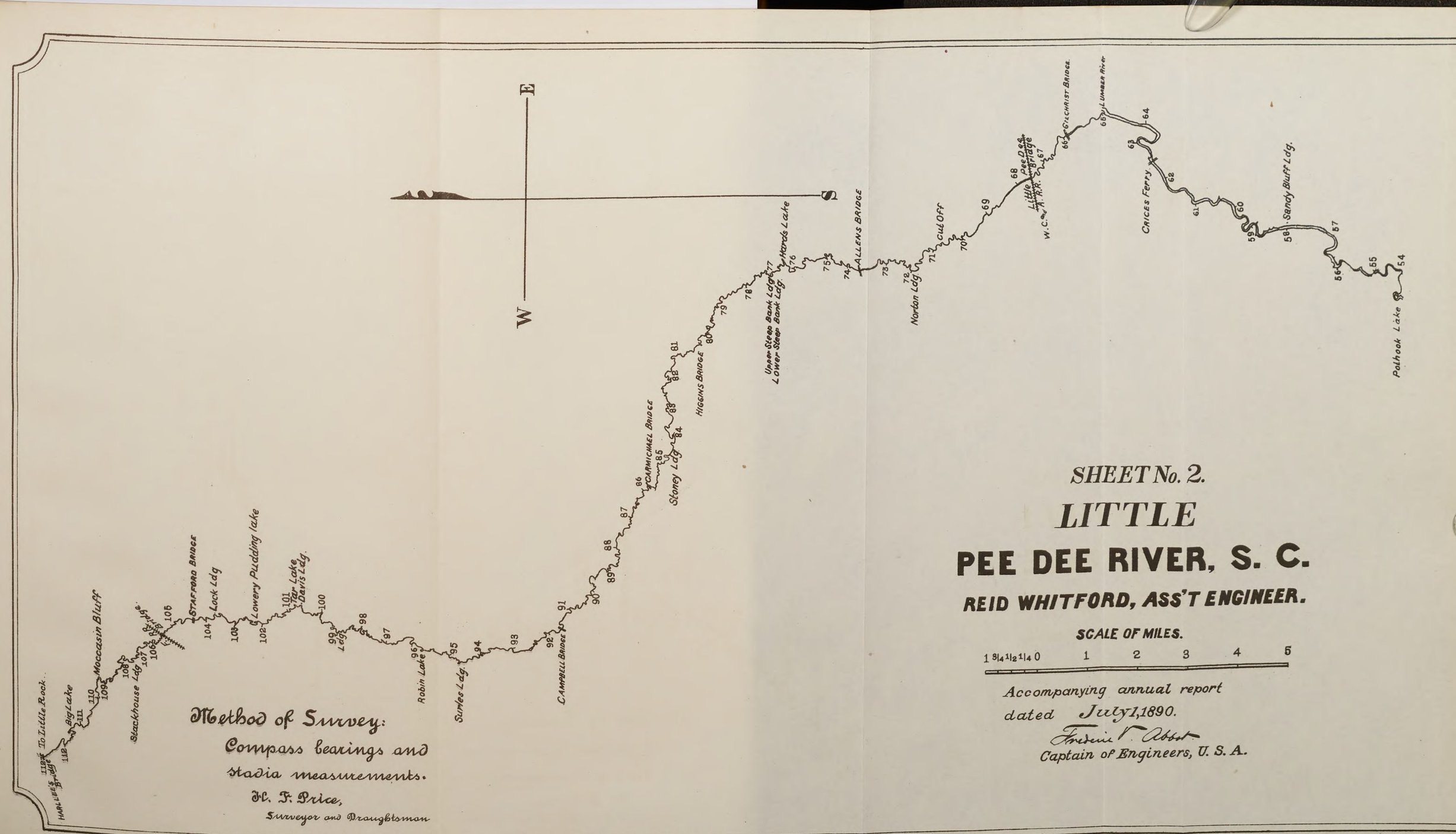
REID WHITFORD, ASS'T ENGINEER.

SCALE OF MILES.

1 3/4 1/2 1/4 0 1 2 3 4 5

Accompanying annual report
dated July 1, 1890.
Frederic V. Abbot
Captain of Engineers, U.S.A.

Method of Survey:
Compass bearings and
stadia measurements.
H. F. Price,
Surveyor and Draughtsman.



Method of Survey:

Compass bearings and stadia measurements.

H. F. Price,

Surveyor and Draughtsman

SHEET No. 2.

LITTLE

PEE DEE RIVER, S. C.

REID WHITFORD, ASS'T ENGINEER.

SCALE OF MILES.

1 3/4 1/2 1/4 0 1 2 3 4 5

Accompanying annual report
dated July 1, 1890.

Frederic V. Abbot
Captain of Engineers, U. S. A.

lower stage of the river than formerly. The completion of the proposed work will greatly improve the facility of the exports and imports on that river and tend to develop a section of country now almost entirely undeveloped for want of cheaper transportation.

I herewith forward you a list of exports and imports coming under my own knowledge.

Respectfully, yours,

S. J. HENNERY.

Mr. REID WHITFORD,
Assistant Engineer.

COMMERCIAL STATISTICS.

Articles.	Quantity.	Value.
OUTWARD.		
	Tons.	
3,726 barrels rosin	745	$4,657
304 barrels spirits turpentine	60	6,840
215 bales cotton	53	10,750
2,000 sticks ton timber	2,000	5,000
Total	2,858	27,247
INWARD.		
Fertilizers	251	.....
General merchandise	152	7,490
Aggregate	3,261	34,737

NOTE.—Tons added by myself. The commerce was carried on by one steam-boat of about 60 tons, and pole-boats.

It was impossible to obtain any accurate statement of the amount of shingles, staves, and the like, shipped down the river on rafts, as well as the amount of general merchandise received overland by wagon from far-off railroad stations, as there seems to have been no account kept.

REID WHITFORD,
Assistant Engineer.

N 9.

IMPROVEMENT OF GREAT PEE DEE RIVER, SOUTH CAROLINA.

REFERENCE TO PAST REPORTS.

For special description of river, see pages 753 to 755, Annual Report for 1873, also pages 845 to 847, Annual Report for 1880, and pages 723 to 726, Annual Report for 1879.

For special history of past work, see page 1019, Annual Report for 1886.

ORIGINAL CONDITION.

In 1880 this stream was dangerously obstructed with snags and logs everywhere. Boats drawing 9 feet of water were able to reach Smith's Mills, 52 miles above the mouth. Those drawing 3½ feet at low water could get 54 miles farther up, to Little Bluff, or at high water to Cheraw, the head of steam navigation, 172 miles above Georgetown. The annual commerce is estimated to have been $400,000.

PLAN OF IMPROVEMENT.

The project provides for a thoroughly cleared 9-foot navigation to Smith's Mills and a 3½-foot navigation to Cheraw at all stages of water.

The estimated cost of this work is $117,000. Inadequate yearly appropriations will add considerably to the final cost.

WORK PRIOR TO JUNE 30, 1889.

The river had been well cleared for 9-foot navigation 52 miles upwards to Smith's Mills, and fairly cleared for 3½-foot navigation at low water 50 miles farther to the railroad station at Pee Dee, or at high water, 110 miles farther, from Smith's Mills to Cheraw. The commerce is rapidly increasing and has already reached 54,000 tons. Since June 30, 1884, 3,093 obstructions, consisting of logs, snags, etc., were removed from the channel, and 5,598 overhanging trees were cut from the banks. Before June 30, 1884, the records are not detailed enough to give exact figures.

WORK OF PAST YEAR.

All work done during the past year has been done by plant owned by the United States and hired labor. The river was quite thoroughly cleared to width of 80 feet and depth of 3 feet at low water between points 42 miles and 166 miles above the mouth. The average cost of removing obstructions from the channel was about $1.24 apiece; overhanging trees, etc., removed from the banks cost about 84 cents apiece. A survey was made of all the shoals between Cheraw and Pee Dee Bridge. For details of work done reference is made to report of my assistant engineer, Mr. Reid Whitford, who has done faithful and efficient work during the year.

REMARKS.

No new transportation lines have been established on the river.

Those using the river report much benefit from this last year's work. With the balance of $3,158.21 on hand July 1, 1890, work will be carried on between Cheraw, at the head of navigation, and the mouth of the river. The worst channel obstructions will be removed first.

This river is in the collection district of Georgetown, S. C., which is the port of entry.

Since the existing project of improvement has been adopted the following appropriations have been made:

By act of Congress approved—	
June 14, 1880	$7,000
March 3, 1881	6,000
By act of Congress passed August 2, 1882	6,000
By act of Congress approved—	
July 5, 1884	8,000
August 5, 1886	20,000
By act of Congress of August 11, 1888	20,000
Total	67,000

The total expenditures, including June 30, 1890, have been $63,841.79.

The following paper accompanies this report:

Report of Mr. Reid Whitford, assistant engineer.

For table of commercial statistics furnished by the collector of Georgetown, S. C., see appendix of the report of this year for Waccamaw River,

Money statement.

July 1, 1889, amount available		$12,238.91
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$9,080.70	
July 1, 1890, outstanding liabilities	627.63	
		9,708.33
July 1, 1890, balance available		2,530.58
Amount appropriated by act of September 19, 1890		12,500.00
Amount available for fiscal year ending June 30, 1891		15.030.58
Amount (estimated) required for completion of existing project		37,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		30,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. REID WHITFORD, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Georgetown, S. C., June 30, 1890.

CAPTAIN: I have the honor to make the following report of operations on Great Pee Dee River, South Carolina, for fiscal year ending with this date:

The two steam-hoisters belonging to the United States, and hired crews, continued snagging and clearing banks till February 1, 1890, when one of them was transferred to Congaree River. The remaining hoister on the Great Pee Dee is still at work.

During the year both hoisters removed the following obstructions from the channel and banks; 431 logs, 298 stumps, 756 large snags, 32 small snags, cords, 3,551 trees cut, 100¾ brush cut, cords. This work extended over the river between points 42 and 166 miles above mouth, quite thoroughly clearing the channel to a width of about 80 feet and depth of 3 feet at low water.

Of the total amount of money expended about six-tenths was used on the channel and four-tenths on the banks. The average cost of removing each obstruction from the channel cost, approximately, $1.24, and from the banks 84 cents.

A steam-launch was built and paid for in part by this appropriation. Three water-gauges were kept during the year. All the shoals upon which there are less than 3 feet at low water, between Cheraw and the Pee Dee Bridge, were surveyed.

REMARKS.

The river has been greatly improved by the removal of obstructions from the channel, as captains of the river steamers, and others in a position to know, freely state.

RECOMMENDATIONS.

It is respectfully recommended that the same character of work be carried on till a thoroughly cleared channel of snags, overhanging trees, be completed from the mouth of the river to Cheraw, and that no effort be made to deepen existing shoals till this shall have been done. No new transportation lines have been established during the year.

COMMERCE.

The accompanying statement of commerce was obtained from the most reliable sources, and it is as correct as it is possible to get it.

EMPLOYÉS.

Thanks are due Mr. Homer Jacobs, overseer, and Mr. H. F. Price, time-keeper, for efficient and excellent work.

Very respectfully, your obedient servant,

REID WHITFORD,
Assistant Engineer.

CAPT. FREDERIC V. ABBOT,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

The following statement of commerce for the year 1889 was furnished by Mr. William P. Holmes, agent South Carolina Steam-boat Company, Mr. D. R. Smith, of Smith's Mills, S. C., and Messrs. Dusenbury and Hennery, at Port Harrelson, S. C.:

Articles.	Quantity.	Value.
OUTWARD FRRIGHTS.		
	Tons.	
5,765 bales cotton	1,950	$288,250
15,460 barrels of rice	2,800	232,000
80,000 bushels rough rice	184	100,000
9,414 barrels spirits turpentine	1,960	170,840
37,906 barrels rosin	8,395	45,657
6,311,000 shingles	18,933	37,866
14,000 sticks timber	11,200	56,000
1,700,000 B. M., feet lumber	2,833	25,500
Total	48,305	956,113
INWARD FREIGHTS.		
Fertilizers, general merchandise, etc	5,703	384,990
Aggregate	54,008	1,341,103

This shows an increase of approximately 7,108 tons over that given in 1888, but a decrease in money value, probably due to shortage in crop of cotton and in the depreciation of value of other products.

The commerce has been carried on by sea-going schooners of 250 to 300 tons, and tug-boats, to Fort Harrelson and Smith's Mills, and the steamers *Farmer*, *Merchant*, and *Santee*, of 200 to 300 tons each, to Cheraw, the head of navigation.

There have been no new lines of transportation established. The business on the river is considered, generally, to be in a healthy condition.

N 10.

IMPROVEMENT OF SANTEE RIVER, SOUTH CAROLINA.

REFERENCE TO PAST REPORTS.

For special description of river, see pages 916 to 919, Annual Report for 1880. For special history of past work, see page 1036, Annual Report for 1886, and for special report of its relation to neighboring rice crops, see pages 1040 to 1053, Annual Report for 1887. For proposed change of project, see Annual Report Chief of Engineers for 1889, pages 1184–1186.

ORIGINAL CONDITION.

In 1880 this river was considerably obstructed at all stages of water by sunken logs and snags; its bar entrance was narrow, crooked, and shifting, with only about 4 feet of water at low tide, and so situated as to be very difficult and expensive to improve. Four steamers and a few small vessels were then running upon portions of the river; its annual commerce is estimated to have been about $600,000.

PLAN OF IMPROVEMENT.

The original project of 1880 proposed to provide the river with a good outlet through Mosquito Creek to Winyaw Bay, by deepening and straightening this creek to 50 feet width and 7 feet depth, to secure a safe and unobstructed 7-foot navigation in the river itself from its mouth 120 miles upward to Wright's Bluff, and thence a similar 5-foot naviga-

tion 23 miles farther to its head in the Congaree and Wateree rivers. A modified project of 1881 proposed that the first expenditure should be to secure a straight canalized outlet through Mosquito Creek 7 miles long, 30 feet wide, and 6 feet deep at low water. The cost of this work was estimated in 1886 at $271,300 for the outlet through Mosquito Creek, and $75,200 for Santee River proper, making $346,500 in all.

WORK PRIOR TO JUNE 30, 1889.

A passage at least 30 feet wide and 5 feet deep at high water through Mosquito Creek to Winyaw Bay has been made. Necessary surveys of the whole improvement had been made, and a draw-bridge over the creek in accordance with the provisions for the cession of right of way for the canal had been built. The creek entrances were narrow, crooked, and shallow, so that only rafts and boats of 75 feet length, 18 feet width, 3 feet draught can pass at low water entirely through from Winyaw Bay to Santee River. The ground on the ocean side of the canal had been drained to solidify and secure the stability of the canal embankment. The effect of all work done has been and will be beneficial rather than detrimental to the rice interests in the neighborhood. The amount of excavation done amounted to 142,865 cubic yards; one dike and five trunks had been constructed.

WORK OF PAST YEAR.

Dredging was continued under the contract with Mr. Charles C. Ely, who completed a cut about 40 feet wide, and 4,417 feet long, with 3 to 6 feet of water in it at low tide. Work was stopped at this point on account of the exhaustion of funds. There is a space of about 1,000 feet between the further end of this cut and the beginning of the cut made in previous years, which still remains to be excavated. Considerable work was done by hired labor, restoring rice-field drainage, which had been injured by the cutting of the canal in this and previous years; this restoration being done in accordance with the terms of the right of way. For details of work done, and commercial statistics, reference is made to the report of my assistant engineer, Mr. Reid Whitford, to whom much credit is due for careful and efficient work.

REMARKS.

The canalized outlet through Mosquito Creek has been considerably used by small craft, and by timber coming from Santee River. The total freights on the Santee River proper have increased by 39,375 tons during the past twelve months. There have been no new transportation lines established. With the balance of $5,257.66 on hand July 1, 1890, a flood gate will be put in to prevent salt-water from entering the canal from Winyaw Bay, and some excavation will be done. The construction of this flood gate is required by the wording of the act of Congress of August 5, 1886, appropriating funds for this improvement.

This work is in the collection district of Georgetown, S. C., which is the port of entry.

Since the existing project of improvement has been adopted the following appropriations have been made:

By act of Congress approved March 3, 1881	$22,000
By act of Congress passed August 3, 1882	20,000
By act of Congress approved July 15, 1884	15,000
By act of Congress approved August 5, 1886	18,750
By act of Congress of August 11, 1888	24.000
Total	**99,750**

The total expenditures including June 30, 1890, $94,492.34.
The following papers accompany this report:

Sketch showing position of dredging.
Report of Mr. Reid Whitford, assistant engineer.

For table of commercial statistics furnished by the collector at Georgetown, S. C., see this year's annual report of Waccamaw River.

Money statement.

July 1, 1889, amount available		$6,837.63
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$1,579.97	
July 1, 1890, outstanding liabilities	60.00	
		1,639.97
July 1, 1890, balance available		5,197.66
Amount appropriated by act of September 19, 1890		30,000.00
Amount available for fiscal year ending June 30, 1891		35,197.66
Amount (estimated) required for completion of existing project		216,750.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		200,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

REPORT OF MR. REID WHITFORD, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Georgetown, S. C., June 30, 1890.

CAPTAIN: I have the honor to make the following report of operations upon Santee River, South Carolina.

Work continued under the project of improving the Santee's outlet into Winyaw Bay, for widening, deepening, and straightening Mosquito Creek, and protecting the cuts thus made from overflowing salt-water. Exhaustion of available funds stopped dredging on August 29, 1889. Work by hired labor continued a month longer, protecting the canal against salt-water and restoring the rice land drainage which had been damaged by the United States Canal work. This was required by the terms of the right of way. The dredge removed 47,792 cubic yards of material, completing a cut about 40 feet wide, 4,115 feet long, and 3 to 6 feet deep at low tide.

The cut lacked about 1,000 feet of reaching Lagoon Creek, where the cut made by dredging in previous years ended. By hired labor, 10,381 cubic yards were removed from the drainage ditches and built into embankment. Five rice-field drainage trunks were built and bedded, and a flood gate was constructed in the drainage ditch near its entrance into Mosquito Creek. The accompanying sketch shows where the work done is located. One water-gauge was kept on the river during the year. A steam-launch was built and paid for in part by this improvement.

GENERAL REMARKS.

The canal and drainage ditch-work is in a very good state of preservation. Minor repairs from time to time will be needed for its maintenance. The canal is being considerably used by small craft in passing to and from Winyaw Bay, and by timber coming from Santee River.

COMMERCE.

The accompanying statement of commerce is furnished by Mr. L. S. Ehrich, president of the Georgetown Board of Trade. Mr. Ehrich takes great pains to have these papers as nearly correct as it is possible to get them; he has given the statistics for this river his personal attention for several years past, and he is in the position—being engaged in large cross-tie and lumber business on the Santee River—to know more about the commerce than any one in this place.

Total freights carried have increased by 39,375 tons over last year. There have been no new transportation lines established.

Very respectfully, your obedient servant,

REID WHITFORD,
Assistant Engineer.

Capt. FREDERIC V. ABBOT,
Corps of Engineers, U. S. A.

IMPROVING

SANTEE RIVER,

S. C.

Mosquito Creek and Estherville Minim Creek Routes.

Reid Whitford, Ass't. Eng'r.

SCALE OF MILES.

0 1 2 3 4

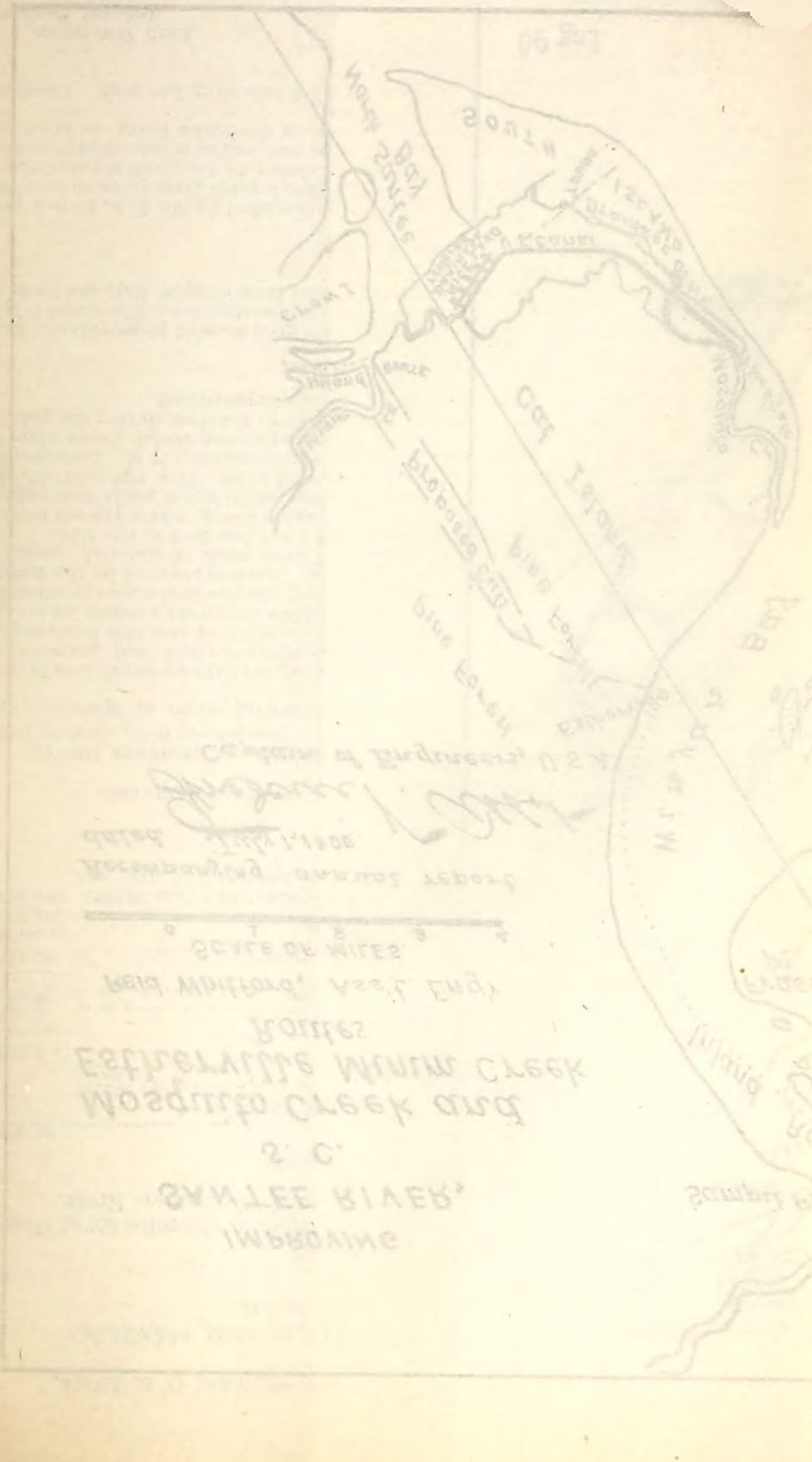
Accompanying annual report dated July 1, 1890.

Frederic V. Abbot

Captain of Engineers, U.S.A.



Eng 90



LETTER FROM MR. L. S. EHRICH, CHAIRMAN, ETC.

GEORGETOWN, S. C., *April* 26, 1890.

DEAR SIR: In compliance with your request of the 21st, I hand you herewith statistics as to Santee River, and regret that my limited time has not allowed me an opportunity of making it as thorough as I would like to have done. I am therefore forced to use some of last year's figures where I am satisfied, inasmuch as crops were good all along the river, that the actual amounts would show considerable increase. The value of the Government cut to owners of lands along the river has fully manifested itself during the past year, and swamp lands which ten years ago were forfeited to the State because the owners did not think them worth taxes, are being speedily redeemed and held at $2.50 now and upwards. Several parties from Michigan have been prospecting all along the river, and those whom I have seen claim that there is a supply of cypress that is almost inexhaustible.

The adoption of the United States engineer's recommendation to make a cut through Minim Creek would no doubt be the means not only of vastly enhancing the value of all timber on Santee River, but make Georgetown one of the largest if not the largest lumber market on the Atlantic coast. You will notice new item in list—railroad ties. This is a branch of business only in its infancy in the South, and there are millions of them on Santee River that will be cut when transportation is practicable.

Very respectfully,

L. S. EHRICH,
Chairman Georgetown Board of Trade.

REID WHITFORD,
Assistant Engineer.

COMMERCIAL STATISTICS.

Year ending April 26, 1890.

	Quantity.	Value.
OUTWARD.		
	* *Tons.*	
Cotton, 15,000 bales	3,750	$750,000
Spirits, 3,800 barrels	760	76,000
Rosin, 150,000 barrels	30,000	180,000
Ton timber, 5,000 pieces	20,000	20,000
Shingles, 5,000,000	2,500	35,000
Lumber, 3,000,000 feet	5,000	30,000
Railroad ties, 36,000	2,160	10,000
Wool, 60,000 pounds	30	12,000
Hides, 15,000 pounds	7	1,500
Staves, 500,000	1,250	2,500
Wood, 3,000 cords	3,000	8,000
Game and fish	30	1,500
Rock, 3,000 tons	3,000	4,500
Total	71,487	1,131,000
INWARD.		
Fertilizers, 6,000 tons	6,000	210,000
Groceries, provisions, 30,000 tons	30,000	300,000
Dry goods (estimated)	4,500	225,000
Boots, shoes, etc	4,200	210,000
Hardware, farming implements, and machinery	1,400	70,000
Aggregate	117,587	2,146,000

* Tons added by myself.—Reid Whitford.

The amount fertilizer is by 1,000 tons in excess of quantity previously used, and with fair season the shipment of cotton will be greatly increased next year.

N 11.

IMPROVEMENT OF WATEREE RIVER, SOUTH CAROLINA.

REFERENCE TO PAST REPORTS.

For special description of river, see pages 914 to 916, Annual Report for 1880. For special history of past work, see page 1057, Annual Report for 1886.

ORIGINAL CONDITION.

In 1882 this stream had a low-water depth of from 3 to 4 feet from its mouth in Santee upward 68 miles to Camden, its present limit of steam navigation. From its mouth upward 14 miles the river was completely blocked at all stages of water by logs and stumps, etc., and at moderate stages by the bridges of the South Carolina and of the Wilmington, Columbia and Augusta railroads, then without draw-spans. On this 54 miles to Camden navigation was possible but dangerous except during high water. Its commerce was practically nothing.

PLAN OF IMPROVEMENT.

The project provides for safe and unobstructed 4-foot navigation over this entire distance at all stages of water. The cost is estimated at $60,000.

WORK PRIOR TO JUNE 30, 1889.

A thoroughly cleared 4-foot navigation at all stages of water from the mouth of the river 11 miles upward, and thence a fairly well-cleared 4-foot navigation 57 miles to Camden had been provided.

WORK OF PAST YEAR.

The act of August 11, 1888, provided that no expenditure should be made from that appropriation until draw-spans should be put in the bridges operated by the South Carolina, and Wilmington, Columbia and Augusta railroads, and approved by the Secretary of War. The Wilmington, Columbia and Augusta Bridge was promptly supplied with a satisfactory draw, but the South Carolina Railway did not complete their structure till late in February 1890, and it was not approved by the Secretary of War till March 3, 1890. This delayed the beginning of work till the latter part of May of that year. During that month a steam-hoister was put in thoroughly good order, and was sent up the river.

The long delay on the part of the South Carolina Railroad Company was partly due to its bad financial condition. Work was pushed forward as soon as it got into the hands of a receiver.

For details of work done, reference is made to the report of my assistant engineer, Mr. Reid Whitford, to whom much credit is due for faithful and efficient work.

REMARKS.

One of the South Carolina Steam-boat Company's steamers has made several trips on the river since the draw-bridge was opened, and this

company proposes to put a regular line of steamers on at once. A steamer to run on this river and the Santee is now under construction by private parties.

With the balance of $7,729.28 on hand July 1, 1890, work will be carried on between Camden and the mouth of the river. The worst channel obstructions will be removed first.

This river is in the collection district of Georgetown, S. C., which is the port of entry.

Since the existing project of improvement has been adopted, the following appropriations have been made:

By act of Congress approved March 3, 1881	$8,000
By act of Congress passed August 2, 1882	15,000
By act of Congress approved July 5, 1884	5,000
By act of Congress approved August 5, 1886	7,500
By act of Congress of August 11, 1888	12,000
Total	47,500

The total expenditures, including June 30, 1890, have been $39,770.72.

The following papers accompany this report:

Report of Mr. Reid Whitford, assistant engineer.

For table of commercial statistics furnished by the collector of Georgetown, S. C., see appendix of this year's report for Waccamaw River.

Money statement.

July 1, 1889, amount available		$12,164.33
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$4,435.05	
July 1, 1890, outstanding liabilities	583.00	
		5,018.05
July 1, 1890, balance available		7,146.28
Amount appropriated by act of September 19, 1890		12,500.00
Amount available for fiscal year ending June 30, 1891		19,646,28

REPORT OF MR. REID WHITFORD, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Georgetown, S. C., June 30, 1890.

CAPTAIN: I have the honor to make the following report of operations on Wateree River, South Carolina, for fiscal year ending with this day.

Work of snagging and clearing banks began upon the river on May 28, 1890, by United States hoister and hired crew. To date the work has been carried on between the mouth and 13 miles above, roughly clearing the channel to about 80 feet width and 4 feet depth at low water. The following obstructions have been removed from the channel and banks: 77 logs, 54 stumps, 137 large snags, 5 small snags, cords, 338 trees cut, 11 brush cut, cords. Of the total amount of money expended about six-tenths of it was used on the channel and four-tenths on the banks. The average cost of removing each obstruction from the channel was about $1.09 and from the banks 57 cents.

A steam-launch and steam-hoister were built during the year and paid for in part by this appropriation. Two water-gauges were kept at two different points on the river.

REMARKS.

The work was greatly delayed in beginning on account of the South Carolina Railway Company's failure to comply with the law in regard to providing their bridge with a proper draw-opening. This has only recently been done, when the appropriation became available.

RECOMMENDATIONS.

It is respectfully recommended that the same character of work be continued till a thoroughly cleared channel to Camden shall have been completed.

COMMERCE.

There is yet no commerce on this stream, but as the South Carolina Steam-boat Company is making arrangements to establish a line of steamers at once between Camden and Charleston, it is but reasonable to believe that a well-paying trade and commerce will soon be developed.

The Wateree flows through an exceedingly rich country in agricultural products, and its resources for timber supply are very great.

Arrangements have also been about completed by private parties to run a steamer from their large saw-mill on the river to Charleston, carrying lumber, shingles, etc. A few trips have actually been made by one of the South Carolina Steam-boat Company's steamers.

EMPLOYÉS.

Much credit is due Mr. Kilbia Morse, overseer, and Mr. E. C. Easterling, time-keeper, for faithful and efficient work.

Very respectfully, your obedient servant,

REID WHITFORD,
Assistant Engineer.

Capt. FREDERIC V. ABBOT,
Corps of Engineers, U. S. A.

N 12.

IMPROVEMENT OF CONGAREE RIVER, SOUTH CAROLINA.

REFERENCE TO PAST REPORTS.

For special description of the river see pages 1140 to 1145 Annual Report for 1885.

ORIGINAL CONDITION.

In 1886 this stream had a low-water depth of 3 to 4 feet from its mouth 48 miles upward to the railroad bridge at Columbia; from thence a 1-foot low-water depth 2 miles further to its head. Navigation of the lower 47 miles from the mouth to Granby was blocked at all stages of water by the South Carolina Railroad Bridge, by sunken logs, snags, and overhanging trees. The navigation of the upper 3 miles above Granby was prevented by swift currents and numerous rock ledges and bowlders. Its commerce was nothing.

PLAN OF IMPROVEMENT.

The project proposes to secure a thorougly cleared 4-foot navigation below Granby at all stages and a cleared channel 100 feet wide through the shoals above Granby.

The estimated cost is $54,500.

WORK PRIOR TO JUNE 30, 1889.

The channel had been fairly well cleared 70 feet wide and 4 feet deep at low water over the river below Granby. A steam-boat had been established on the river. A steam-hoister, or snag-boat, had been built for the river, and 400 logs, snags, etc., had been removed from the bed and 322 trees cut from the banks.

The South Carolina Railroad Company had put in a draw in their bridge across the river near its mouth, but had not complied with all the requirements of the law of August 11, 1888, which provided that no expenditure should be made from the river and harbor appropriation of that date until the draw-span put in during the year by the South Carolina Railroad Company had been approved by the Secretary of War.

WORK OF PAST YEAR.

The provisions of the law just referred to prevented work from beginning till after January 22, 1890, at which time the approval of the Secretary of War was obtained for the draw-bridge put in by the South Carolina Railroad Company.

Since that date 47 miles of the river have been worked over and fairly well cleared. For details of work done see report of my assistant engineer, Mr. Reid Whitford, to whom much credit is due for faithful and efficient work.

REMARKS.

As soon as the draw-span was completed a steam-boat was put upon the river, and it has continued running regularly ever since. During the latter part of the year two steamers ran part of the time.

With the balance, $2,089.01, on hand July 1, 1890, work will be carried on between Granby and the mouth of the river. The worst obstructions will be removed first.

This river is in the collection district of Georgetown, S. C., which is the port of entry.

Since the existing project of improvement has been adopted the following appropriations have been made:

By act of Congress approved August 5, 1886	$7,500
By act of Congress of August 11, 1888	7,500
Total	15,000

The total expenditures, including June 30, 1890, have been $12,910.99.

The following papers accompany this report:

Report of Mr. Reid Whitford, assistant engineer.

For table of commercial statistics furnished by collector of Georgetown, S. C., see appendix of this year's report for Waccamaw River.

Money statement.

July 1, 1889, amount available		$7,564.35
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$5,475.34	
July 1, 1890, outstanding liabilities	438.83	
		5,914.17
July 1, 1890, balance available		1,650.18
Amount appropriated by act of September 19, 1890		5,000.00
Amount available for fiscal year ending June 30, 1891		6,650.18
Amount (estimated) required for completion of existing project		34,500.00
Amount that can be properly expended in fiscal year ending June 30, 1892.		25,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

REPORT OF MR. REID WHITFORD, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Georgetown, S. C., June 30, 1890.

CAPTAIN: I have the honor to make the following report of operations on Congaree River, South Carolina, for fiscal year ending with this date.

Work began with United States steam hoister and hired crew February 21, 1890, at mouth of river. To date the work has been carried on between points 0 and 47 miles above the mouth, roughly clearing a channel about 80 feet wide, and 3 feet deep at low water. The following obstructions have been removed from the channel and banks: 346 logs, 148 stumps, 616 large snags, 32½ small snags, cords, 450 trees cut, 8 brush cut, cords.

Of the total amount of money expended about eight-tenths was used on the channel and about two-tenths on the banks. Channel obstructions cost $1.50 each; bank, 80 cents each.

A steam-launch and steam-hoister were built during the year and paid for in part by this improvement. Two water-gauges were kept at two different points on the river.

REMARKS.

The beginning of the work was greatly delayed because of the failure of the South Carolina Railway Company to provide their bridge with a proper draw-opening, as required by law. As soon as this was done, the appropriation became available, and work began.

RECOMMENDATIONS.

It is respectfully recommended that the same character of work be continued till a thoroughly cleared channel from the mouth of the river to Granby Landing, near Columbia, be completed.

COMMERCE.

The accompanying commercial statement was obtained from the most reliable sources. It is as correct as it is possible to get it.

EMPLOYÉS.

Thanks are due Mr. George T. Sandford, overseer, R. G. Dusenbury, time-keeper, and John R. Smith, engine-driver, for excellent and efficient work.

Very respectfully, your obedient servant,

REID WHITFORD,
Assistant Engineer.

Capt. FREDERIC V. ABBOT,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS FOR YEAR 1889.

[Furnished by Mr. William P. Holmes, agent of South Carolina Steam-boat Company.]

	Quantity.	Value.
	Tons.	
Spirits turpentine, 228 barrels	46	$4,100
Rosin, 6,736 barrels	1,675	8,100
Fertilizers, 5,090 sacks	509	1,764
Total	2,230	13,964

There are probably other freights, such as shingles, lumber, timber, etc., of which no account whatever could be obtained. In the year 1888, the commerce amounted to approximately 700 tons; in 1889, it was 2,230 tons, as above, showing an increase of 1,530 tons.

This river is the city of Columbia's water outlet to the ocean.

There have been no new transportation lines established, but the South Carolina

Steam-boat Company put on a boat of greater carrying capacity, about 300 tons, and their boats have made a number of extra trips during the year.

The South Carolina Railway Company completed their draw-bridge in a satisfactory manner to the United States.

The Congaree flows through an exceedingly fertile country, and a large and important commerce, will, no doubt, soon be established.

N 13.

IMPROVEMENT OF WAPPOO CUT, SOUTH CAROLINA.

REFERENCE TO PAST REPORTS.

For original project of improvement see Appendix J 4, Annual Report of the Chief of Engineers for 1881. For modified project see Annual Report of Chief of Engineers for 1889, page 1196.

ORIGINAL CONDITION.

Wappoo Cut was a narrow, crooked, tidal stream, with but little depth, connecting Ashley and Stono rivers.

PLAN OF IMPROVEMENT.

The project provides for securing a sufficiently straight and convenient channel, 60 feet wide, between low-water lines, and 6 feet deep at low water all the way through from Ashley to Stono River. The bulk of the work is dredging.

To maintain the channel two training-walls at the Stono entrance and three closing dams are to be made and some bank protection done. The estimated cost was $88,000.

WORK PRIOR TO JUNE 30, 1889.

Operations were first begun in November, 1882. One hundred and thirty-seven thousand one hundred and ninety-five cubic yards of dredging had been done. A number of snags, stumps, and overhanging trees had been removed, and a bulkhead had been built across the mouth of Pompey's Cut. The south side of Elliott's Cut had been revetted with stone for a length of 1,300 feet.

WORK OF PAST YEAR.

No work has been done, as the balance, $1,650 on hand, was reserved for dredging in case the channel should shoal before additional funds were supplied to continue the project. One new side-wheel steamer has been using the cut during the year.

REMARKS.

A survey made in May, 1890, indicates shoaling in some portions but not to such an extent as to interfere with commerce. The washing away of the banks of Elliott's Cut and neighboring reaches has thrown some snags into the way of passing boats. For details of this survey reference is made to the report of my assistant engineer, Mr. James P. Allen, to whom much credit is due for faithful and efficient work. With

a balance of $1,646 on hand July 1, 1890, no work will be done unless the shoaling proceeds far enough to interfere with the navigation. If further funds are provided they will be used in dredging upon the marsh cut just east of Elliott's Cut, in accordance with the revised project.

This work is in the collection district of Charleston, S. C., which is the port of entry. Amount of duties collected in the calendar year 1889, $16,728.82.

The following appropriations have been made for this improvement:

By act of Congress approved March 3, 1881	$10,000
By act of Congress passed August 2, 1882	10,000
By act of Congress approved July 5, 1884	3,000
By act of Congress approved August 5, 1886	5,000
By act of Congress of August 11, 1888	5,000
Total	33,000

The total expenditures to June 30, 1890, were $31,354.

The following papers accompany this report:

Report of Mr. James P. Allen, assistant engineer.

Money statement.

July 1, 1889, amount available	$1,650.00
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	4.00
July 1, 1890, balance available	1,646.00
Amount appropriated by act of September 19, 1890	10,000.00
Amount available for fiscal year ending June 30, 1891	11,646.00
Amount (estimated) required for completion of existing project	45,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	45,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. JAMES P. ALLEN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Charleston, S. C., June 30, 1890.

CAPTAIN: I have the honor to submit the following report upon the improvement of Wappoo Cut, South Carolina:

No work has been done during the fiscal year ending June 30, 1890. An examination of the cut was made in May, 1880, showing some shoaling, more especially in the improved reaches just east of Elliott's Cut. In the first of these there is still a channel 6 feet deep at mean low water, but at the end of the second reach, going eastward from Elliott's Cut, there is a break in the 6-foot channel for a short distance. Here the depth shoals to about 5.8 feet. In the long reach approaching the Marsh Cut from the west there is but little change. Some shoaling is indicated just west of Marsh Cut. The depths in Marsh Cut have not changed materially. There is a good channel through Elliott's Cut of over 6 feet at mean low water, generally from 7 to 9 feet. The Stono and Ashley bars both show channels of over 6 feet. The riprap shore-protection on south bank of Elliott's Cut shows some deterioration, but may be said to be in fair condition. Complaints have been made of snags in Elliott's Cut, and in the first bend east of this cut. The snags in Elliott's Cut, which seem to be mainly on the north side, should be removed at an early date, also trees and stumps on the banks now threatening to fall in. It seems desirable to leave for the present those in the bend referred to, unless they are very dangerous to existing commerce, because under the present project the first two reaches east of Elliott's Cut will not be used in the improvement, which contemplates a new marsh cut across the point from Pompey's Cut eastward. For the same reason it is best to avoid dredging in these reaches, although they show the greatest shoaling. Complaint has also been made of obstructions, both in Stono and Ashley mouths of the cut. No examination

has been made of these, but they are believed to be of a temporary nature, as submerged logs or sticks of timber.

Very respectfully, your obedient servant,

JAMES P. ALLEN,
Assistant Engineer.

Capt. FREDERIC V. ABBOT,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

[Furnished by Mr. E. Willis.]

Wappoo Cut, near Charleston, S. C., has some commercial significance, being a link in the system of inland navigation from Charleston, S. C., to Jacksonville, Fla., and very important to Beaufort and Savannah, beside supplying many of the sea islands, and the improvements from money expended by the United States Government has greatly shortened the route and reduced materially the risk to steamers and sail-vessels, and the last year will show for itself.

Articles.	Unit of quantity.	1888.		1889.	
		Quantity.	Value.	Quantity.	Value.
Phosphate rock	Tons	60,000	$300,000	75,000	$450,000
Sea Island cotton (825 tons)	Bags	6,000	360,000	5,500	340,000
Rice (3,416 tons)	Bushels	150,000	150,000	155,000	155,000
Vegetables (2,500 tons)	Crates	120,000	240,000	110,000	220,000
Fertilizers	Tons	2,000	30,000	3,000	45,000
Lumber and timber (500,000 tons)	Feet	20,000,000	160,000	25,000,000	200,000
Shingles and miscellaneous articles (500 tons).					20,000
			1,240,000		1,430,000

Total tonnage, 190,000 tons.

N 14.

IMPROVEMENT OF WACCAMAW RIVER, NORTH AND SOUTH CAROLINA.

REFERENCE TO PAST REPORTS.

For special description of river see pages 818 to 851, Annual Report for 1880, and pages 1056 to 1058, Annual Report for 1884. For special history of past work see page 1024, Annual Report for 1886.

ORIGINAL CONDITION.

The Waccamaw River has a total length of about 147 miles and a drainage area of 1,572 square miles. In 1880 this stream was navigable for 12-foot boats at all stages of water from Georgetown, 23 miles, to Bull Creek, and at high water, 46 miles further to Buck's Lower Mills; thence for 7-foot draught boats, at high water, 22 miles further to Conway; thence it possessed an obstructed channel for 3-foot draught boats, at ordinary winter water, 68 miles to Reeves Ferry, the present head of steam navigation; thence an obstructed channel, with 3 feet at high water, for 30 miles to Lake Waccamaw.

The commerce of this river is estimated to have been about $400,000 per year.

PLAN OF IMPROVEMENT.

The project provides for a channel 12 feet deep at all stages of water, with 80-foot bottom width from the mouth of the river upward to Conway; thence a cleared channel to Lake Waccamaw. The estimated cost is $138,400. Inadequate yearly appropriations will increase the final cost.

The aggregate amount appropriated for this project up to June 30, 1890, is $65,400.

WORK PRIOR TO JUNE 30, 1889.

At eight shoals, jetties made of piles and plank were put in. One thousand one hundred and nine large obstructions had been removed from the bed of the river, and 4,734 leaning trees, etc., had been cut from the banks. By these means a thoroughly cleared channel of 100 feet wide and 8.8 feet deep at high water had been provided as far as Conway, and 45 feet wide, and 3 feet deep, for 72 miles above Conway.

In consequence of this improvement, 4 steam freight boats and 2 steam tugs use the lower river during the entire year, and 1 light-draught steamer uses the upper river nearly all the year. The commerce of the river is rapidly increasing, and has already reached about $2,317,000.

WORK OF PAST YEAR.

Work has been continued with a hoister and crew hired from Mr. Thomas W. Dagget, of Conway, S. C. Work has been confined to that part of the river between 32 miles and 88 miles above its mouth, providing a channel 40 feet wide and 3 feet deep at low water.

For details of work done reference is made to report of my assistant engineer, Mr. Reid Whitford, to whom much credit is due for faithful and efficient work. There has been an increase of about $9,000 in the commerce upon this river, as compared with the preceding year.

REMARKS.

No new line of transportation has been put upon this river. Considerable benefit has resulted from the last 12 month's work. With the balance of $224.87 on hand July 1, 1890, Government plant and records will be cared for. It is too small to admit of further work on the river unless more money is provided.

This river is tributary to the collection district of Georgetown, S. C. Georgetown is the port of entry.

For this improvement the following appropriations have been made:

By act of Congress approved:—	
June 14, 1880	$15,000
March 3, 1881	10,000
By act of Congress passed August 2, 1882	4,400
By act of Congress approved:—	
July 5, 1884	6,000
August 5, 1886	15,000
By act of Congress of August 11, 1888	15,000
Total	65,400

The total expenditures, including June 30, 1890, were $65,175.13.

The following papers accompany this report:

Report of Mr. Reid Whitford, assistant engineer.
Statistical letter from Mr. Thomas W. Daggett,

Table of commercial statistics furnished by the collector of Georgetown, S. C.

Money statement.

July 1, 1889, amount available		$5,436.42
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$5,211.55	
July 1, 1890, outstanding liabilities	50.00	
		5,261.55
July 1, 1890, balance available		174.87
Amount appropriated by act of September 19, 1890		12,500.00
Amount available for fiscal year ending June 30, 1891		12,674.87
Amount (estimated) required for completion of existing project		60,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		30,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. REID WHITFORD, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Georgetown, S. C., June 30, 1890.

CAPTAIN: I have the honor to make the following report of operations on Waccamaw River, North and South Carolina, for fiscal year of 1889–'90.

Snagging and clearing banks was done by Mr. Daggett's hired hoister and crew to November 27, 1889, when it ceased because of the appropriation having been exhausted. The work was done between the following points: 82 to 83 miles, 49 to 32 miles, 78 to 87½ miles, and 87½ to 74 miles from the mouth, thoroughly clearing the channel to a width of 40 feet and depth of 3 feet at low water. The obstructions removed were as follows: 627 logs, 191 stumps, 173 large snags, 6 cords of small snags, 1,775 trees, and 131 cords of brush. Of the total amount expended about one-half was used in removing obstructions from the channel, and one-half in cutting them from the banks; the cost was approximately $1.92 apiece for those taken from the water, and $1 apiece for bank cutting. A water-gauge has been kept during the year at Conway, and another for several months at Georgetown. A steam-launch was built and paid for in part by this appropriation.

REMARKS.

The owners and captains of the steamers express themselves as highly pleased with the work.

Mr. Daggett showed his usual and untiring energy in working for the success of the improvement.

RECOMMENDATIONS.

It is respectfully recommended that work be carried on above Conway as it has been this year, and the channel below Conway be maintained at least at its present width and depth.

COMMERCE.

The accompanying letter relating to the commerce has been furnished this office by Mr. Daggett. The amount of tonnage of exports and imports were added by myself. Total freights carried have increased by about 9,867 tons over last year. There have been no new transportation lines established, but boats have made more trips.

EMPLOYÉS.

The employés have shown their usual efficiency and faithfulness in the discharge of their duties. I am particularly indebted to Mr. William Alden James, clerk.

Very respectfully, your obedient servant,

REID WHITFORD,
Assistant Engineer.

Capt. FREDERIC V. ABBOT,
Corps of Engineers, U. S. A.

LETTER FROM MR. THOMAS W. DAGGETT.

Conway, S. C., April 19, 1890.

SIR: At your request I give below the commerce on the Waccamaw River, North and South Carolina, during the past year. This report is as nearly correct as it could be made under ordinary circumstances. Considerable commerce is carried on by pole-boats, rafts, and the like, of which no account whatever could be obtained. The steamers running on the Waccamaw River are as follows: *Planter*, about 450 tons, to Waverly Mills and Charleston; *Merchant*, 400 tons, to Waverly Mills and Georgetown; *Maggie*, about 240 tons, from Georgetown to a point 84 miles above; *Driver*, about 160 tons, from Georgetown to a point about 84 miles above; *Ruth*, about 90 tons, from Georgetown to a point 117 miles above; *Janie*, about 10 tons, from Georgetown to Bucksville, distance 38 miles.

Sea-going vessels of about 350 to 400 tons are towed by tug boats *Congdon* and *Brewster*, of about 50 tons each, to Bucksville, where the vessels load with lumber, shingles, etc. The tug *Fearless*, about 15 tons is used for towing rice to Waverly Mills.

No approximation can be made of the tonnage of pole-boats and small craft used on the river.

COMMERCIAL STATISTICS.

Articles.	Quantity.	Value.
EXPORTS.	*Tons.*	
78,083 barrels rosin	15,616	$282,036.00
9,259 barrels spirits turpentine	1,851	183,487.50
5,639 bales cotton	1,409	282,000.00
8,617,493 feet lumber	19,360	122,664.00
4,264,850 shingles	2,132	29,240.00
Miscellaneous articles, such as tallow, honey, wax, eggs, poultry, fish, game, etc	2,000	93,202.00
11,360 barrels clean rice	1,988	170,400.00
123,455 bushels rough rice	2,839	154,339.00
IMPORTS.		
General merchandise	20,000	1,000,000.00
	67,195	$2,317,368.50

As will be observed, the total commerce shows a little increase in value over that reported last year. The increase has been no greater, because possibly it has been kept down by short crops and the incomplete state of the improvement, the river being low a large part of the year, rendering it impossible to run the steamers on the upper river with regularity. Aside from this, as before stated, it has been impossible to obtain satisfactory accounts from all sources of trade.

Respectfully, your obedient servant,

THOMAS W. DAGGETT.

Mr. REID WHITFORD,
Assistant Engineer.

COMMERCIAL STATISTICS.

Arrival and clearances of vessels and commerce at Georgetown, South Carolina, from January 1, 1888, *to December* 31, 1889.

ARRIVED.

Year.	Coastwise.			Foreign ports.						Total.		
				American vessels.			Foreign vessels.					
	No.	Tons.	Crew.	No.	Tons.	Crew.	No.	Tons.	Crew.	No.	Tons.	Crew.
1888....	352	124,155	2,818	2	479	14	1	81	8	355	124,715	2,840
1889....	365	128,705	2,920	2	424	10	1	149	7	368	129,278	2,943
CLEARED.												
1888....	342	121,715	2,735	8	1,835	55	1	81	8	351	123,631	2,798
1889....	357	126,965	2,856	6	1,494	45	1	149	7	364	128,608	2,908

Commerce—foreign and domestic.

Year.	Value of exports.	Value of imports.	Duties collected.
1888	$3,125,000	$2,750,000	$32.44
1889	3,265,000	2,975,000	.....

Total commerce, 1888 ..... $5,875,000
Total commerce, 1889 6,240,000

R. O. BUSH.

N 15.

REMOVING SUNKEN VESSELS OR CRAFT OBSTRUCTING OR ENDANGERING NAVIGATION.

Complaint having been made of a wreck lying in South Channel on Charleston Bar, upon which several vessels had struck and injured themselves, the matter was investigated, and the wreck was found to be an obstruction to navigation. The usual notice to parties interested was published February 19, 1890, and as no action was taken by parties interested, proposals were invited and opened at 12 o'clock, noon, of March 21, 1890, for the removal of the wreck and cargo. Only one bid was received, and as it was deemed reasonable, the contract was awarded to the bidder, Mr. K. S. Tupper, of Charleston, S. C.

The wreck proved to be a consolidated mass of old guns, chain, and bar shot, and other antiquated ordnance material cemented together by iron rust. No authentic and reliable information can be obtained as to the name of the vessel carrying this cargo, or the date on which it was sunk on the bar. The thoroughly rusted condition of the guns and shot, appear to indicate that the wreck must have occurred a considerable number of years ago.

At the close of the fiscal year the wreck had not been entirely removed to the required depth, although but little further work remained to be done.

Fifty-four old cast iron guns, a part of a windlass, and a buoy sinker, belonging undoubtedly to the Light-House Department, had been raised and brought to the city for sale, and a number of charges of dynamite had been exploded to level down the piles of consolidated shot into deeper water alongside of the wreck. The specifications called for removing the wreck to a depth of 12½ feet below mean low water. At the end of the fiscal year about 12 feet had been obtained.

Abstract of proposals for removal of wreck on Charleston Bar to a depth of 12½ feet below mean low water, received and opened at 12 o'clock, noon, of March 21, 1890, by Frederic V. Abbot, Captain, Corps of Engineers.

No.	Name of bidder.	Price.
1	K. S. Tupper, Charleston, S. C.	$3,445

Contract (dated April 1, 1890), awarded to K. S. Tupper.

N 16.

PRELIMINARY EXAMINATION OF BEAUFORT RIVER, FROM A POINT THREE MILES SOUTH OF THE TOWN OF BEAUFORT THROUGH TO COOSAW RIVER, WITH VIEW TO ITS IMPROVEMENT, ESPECIALLY AT BRICKYARD, SOUTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
Charleston, S. C., November 23, 1888.

GENERAL: I have the honor to submit the following report of a personal examination made in accordance with the following clause of the river and harbor act of August 11, 1888:

SEC. 13. That the Secretary of War is hereby directed, at his discretion, to cause examinations or surveys, or both, to be made, and the cost of improvement to be estimated at the following localities, to wit: In the States of

* * * * * * *

SOUTH CAROLINA.

* * * * * * *

Beaufort River, from a point 3 miles south of the town of Beaufort through to Coosaw River, with view to its improvement, especially at Brick Yard.

Vessels drawing 28 feet can enter Port Royal Sound from the ocean and come up toward Beaufort as far as Battery Creek. They can go up this creek to Port Royal, but if it is desired to go to Beaufort much less draught can be carried. At ordinary tides not much over 18 or 19 feet at high water can go up to the city. The main obstructions are found at Old Fort, about 1 mile above Battery Creek, at Fort Charlotte, about 2 miles further up, and two or three shoals in front of the city. The object, which is desired by the citizens, is to have these shoals deepened so as to give 15 feet at mean low water, thus allowing vessels drawing 22 feet to come up to the city at ordinary high tides.

In 1880 this river was partially surveyed under the direction of Col. Q. A. Gillmore, late of the Corps of Engineers, who writes as follows regarding this improvement:

As the Port Royal Railroad, having its terminus and wharves on deep water below the shoals referred to, connects the harbor of Port Royal Sound with Augusta and the Western Railroad system, passing close by the town of Beaufort, there would seem to be little if any necessity for making the improvements that have been described, for the reason that all freights arriving from the interior for transportation to foreign or domestic ports would be transferred to ocean-going vessels at the railroad wharves, and all freights arriving by vessels at Port Royal Sound for transfer to the interior would be loaded into railroad cars at the same place.

The only reasons for changing the recommendations of Colonel Gillmore are that since 1880 the phosphate interests of Coosaw and Beaufort rivers have greatly increased, and every effort to make Port Royal a large shipping point has so far been a failure, while the business of Beaufort has, if anything, increased. I have been unable to get any full statistics of local business, none having been kept.

In order to come to a fair decision as to whether this portion of the river is worthy of improvement, it is necessary to have a sufficiently accurate survey to estimate the cost involved. If the cost should be small I consider this portion of the river worthy to be improved; if a survey shows that this improvement will probably be expensive, I consider this portion of the river unworthy of improvement for sea-going vessels.

From Beaufort to Coosaw River the question is entirely different. This is part of the inland route between Charleston, S. C., and Florida, which the United States has indicated the intention of improving by work already done at Wappoo Cut, Romerly Marsh, Jekyl Creek, etc. The adopted depth of improved route has generally been between 6 and 7 feet at mean low water. As the range of tides is about 8 feet I recommend the larger limit here, so that at spring tides 6 feet may be available at low water. For the first 6 miles this depth is now available, but in the next mile there are two short shoals. The first is of mud, probably covering phosphate rock at a slight depth. About 4 feet is all that can be carried over it at low water. The second shoal is of sand, probably with the same underlying material; it is very near the Coosaw mouth of Beaufort River. The 4 miles of Beaufort River next to Coosaw River are generally known as Brick-Yard Creek.

The removal of these two shoals would probably be not very costly, unless the rock proved hard, but there appears to be a meeting of the tides in this vicinity, and the cuts would probably fill up after a time. It would be more economical to redredge at intervals, than to attempt to make the depth self-sustaining by jetties, etc.

There is a large traffic passing through this route, of which I hope to obtain reasonably complete statistics to accompany the report of the survey, but which I can not get in time for this report.

I consider this portion of the river worthy of improvement, as part of the important inland navigation route, and ask that $900 be allotted for a survey to enable me to prepare estimates of cost and detailed projects.

Very respectfully, your obedient servant,

FREDERIC V. ABBOT,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

SURVEY OF BEAUFORT RIVER, FROM A POINT THREE MILES SOUTH OF THE TOWN OF BEAUFORT THROUGH TO COOSAW RIVER, WITH VIEW TO ITS IMPROVEMENT, ESPECIALLY AT BRICK-YARD, SOUTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
Charleston, S. C., November 26, 1889.

GENERAL: I have the honor to submit the following report of a survey made in accordance with the following clause of the river and harbor act of August 11, 1888:

SEC. 13. That the Secretary of War is hereby directed, at his discretion, to cause examinations or surveys, or both, to be made, and the cost of improvement to be estimated at the following localities, to wit: In the States of

* * * * * * *

SOUTH CAROLINA.

* * * * * * *

Beaufort River, from a point three miles south of the town of Beaufort through to Coosaw River, with view to its improvement, especially at Brick-Yard.

In my preliminary report, dated November 23, 1888, upon Beaufort River, etc., it was stated that vessels drawing 28 feet could enter Port

Royal Sound from the ocean, and pass up to the town of Port Royal through Battery Creek. Beaufort River, between Battery Creek and the town of Beaufort, is obstructed by two or three shoals. The citizens of Beaufort desire a channel 15 feet deep at mean low water from deep water to the wharves at Beaufort. In my preliminary report I further stated that in order to arrive at a fair decision as to whether this portion of the river is worthy of improvement by the United States, a survey was necessary. The survey has been made.

In front of the town of Beaufort the shoal has been closely sounded. The shoal near the Sea Island Chemical Works has also been carefully sounded, and the remaining portions of the river between Beaufort and mouth of Battery Creek, have been carefully examined by running zig-zag lines of soundings across the river. A few borings were made to determine the character of material to be removed.

Careful study of these surveys and examinations shows that in order to secure a good 15-foot channel 300 feet wide from Beaufort to the ocean the following material must be removed.

From the shoal at Beaufort:	
6,000 cubic yards of sand, at 25 cents a yard	$1,500
24,000 cubic yards of rock, at $1 a yard	24,000
Total at this shoal	25,500
From the shoal near the Sea Island Chemical Works:	
40,000 cubic yards of rock, at $2 a yard	80,000
Total at both shoals	105,500
Add about 10 per cent. for contingencies	10,500
Amount required for the improvement	116,000

No estimate is made for dredging the shoal at Old Fort mentioned in my preliminary report, as the survey shows that all that is needed is to have the existing channel properly marked.

Any less work than that above estimated for would be of but little benefit to commerce, as there is a channel of little less than 14 feet at the Chemical Works, and the shoal in front of Beaufort does not prevent vessels from coming up to the wharves, although it is a serious inconvenience.

A channel less than 300 feet wide through these rock shoals would be insufficient for large vessels.

The cost of rock dredging on the shoal near the city is estimated at $1 a yard, as this rock is probably phosphate which would partially repay the contractor for the cost of removal. At the Chemical Works shoal the rock is hard and valueless, and $2 a yard is the least price at which it could be excavated.

The commerce at Beaufort is at present small, and there is deep water already up to the wharves at Port Royal, only 5 miles distant. On account of the large cost I consider this portion unworthy of improvement.

From Beaufort to Coosaw River the inland route passes through what is usually known as Brick-Yard Creek, which is a tidal stream about 7½ miles long, possessing a fairly good 7-foot low-water channel except at the point called Brick-Yard, near the Coosaw mouth; here the 7-foot channel disappears altogether, as shown on the accompanying map* at "A," and at "B" it is too narrow. At "C" there is a shoal under the point which is a serious obstruction, although there is a narrow deep channel around it. Borings indicated that the material composing these

*Omitted; printed in House Ex. Doc. No. 42, Fifty-first Congress, first session.

shoals was sand and mud underlaid with some kind of rock, probably phosphate, at a depth of 8 or 10 feet below low water. As it is known that this class of rock lies in very uneven strata, and as the number of borings was very small on account of the small amount of money allotted for this survey, it is deemed necessary to estimate for some rock excavation to secure the 7-foot channel recommended in my preliminary report. No provision is made in the estimate for contracting works, as they would interfere with the free entrance of the tide from Coosaw River.

As Brick-Yard Creek forms a link in the inland passage from Charleston to Florida, and as its local business is large, I consider this point well worthy of improvement by the United States.

ESTIMATE OF COST.

50,000 cubic yards of sand, at 25 cents a yard	$12,500
10,000 cubic yards of rock, at $1 a yard	10,000
	22,500
Add about 10 per cent. for contingencies	2,500
Total	25,000

This estimate covers a good 7-foot low-water channel 200 feet wide, which is as narrow as will properly accommodate the existing commerce. After this improvement is completed subsequent dredging at intervals will be required, and for this $5,000 appropriated each five years will be sufficient. If the work is undertaken the whole $25,000 should be appropriated in one sum. Small appropriations might easily double the ultimate cost. These surveys were conducted by Mr. R. G. Thomas, to whom much credit is due for the efficient manner in which the work was done and the large amount of valuable information obtained with the small amount allotted. His map is submitted herewith. Some of the shore lines have been taken from the Coast and Geodetic Survey chart, but all the soundings are derived from his survey.

I have been unable to obtain very satisfactory statistics, but a number of letters are appended which contain all the information I have been able to gather.

Very respectfully, your obedient servant,

FREDERIC V. ABBOT,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

LETTER OF MR. F. W. SCHEPER.

BEAUFORT, S. C., *July* 10, 1889.

DEAR SIR: By request of Col. William Elliott I send you the following statistics, which will cover the inquiry made in yours of June 26 of the colonel.

Average tonnage passing Brickyard per year about 325,000 tons; total value of cargo about $2,250,000.

These figures are about as near to the mark as I possibly could make.

Very respectfully,

F. W. SCHEPER,
Per L.

F. V. ABBOT,
Captain of Engineers.

LETTER OF MR. GEORGE WATERHOUSE, AGENT STEAMER PILOT BOY.

BEAUFORT, S. C., *July* 8, 1889.

SIR: In answer to a request through Colonel Elliott for the amount of tonnage of steamer *Pilot Boy* and value of cargoes passing through Brickyard Creek in a year, I beg to report as follows:

Number of trips 120; tonnage 329; gross equals 39,480 tons; value cargoes of miscellaneous merchandise, say $1,000 per trip, $120,000.

Very respectfully, your obedient servant,

GEORGE WATERHOUSE,
Agent Steamer Pilot Boy.

Captain F. V. ABBOT.

LETTER OF MESSRS. J. J. DALE & CO.

ST. HELENA ISLAND, S. C., *July* 8, 1889.

DEAR SIR: We have been handed by the Hon. William Elliott copy of your letter of June 26 to him relative to tonnage and value passing yearly through Brickyard Creek, and complying with his request we beg to state that the schooner *C. A. Raynor*, of 31 tons register, of which we are owners, makes about one hundred trips annually through the creek, and the aggregate value of her cargoes is about $100,000.

Very respectfully,

J. J. DALE & CO.

F. V. ABBOT,
Captain of Engineers.

LETTER OF SEA ISLAND CHEMICAL COMPANY.

BEAUFORT, S. C., *January* 9, 1889.

DEAR SIR: Col. William Elliott, member of Congress, has requested us to forward to you an estimate of the yearly tonnage that passes through Brickyard Creek to and from our works. This is difficult to arrive at accurately, but the following will give a fair idea of what we handle, and is within the actual figures.

Since last March the steamer *Reliance* (62 tons register) has averaged one trip each way through Brickyard Creek per working day (Sundays excepted) with a tow averaging two lighters (will register 90 tons each) each way. This makes 484 tons daily, or 151,008 tons yearly. In addition to this, all of our dredges and washers (5) have been towed through (they will register about 1,013 tons), and one dredge and washer (466 tons) towed back, which would make the yearly estimate 152,487 tons.

Hoping that these figures may answer your purpose, we remain,

Yours, respectfully,

SEA ISLAND CHEMICAL CO.
D. C. WILSON, JR.

Captain ABBOT,
Corps of Engineers.

LETTER OF THE PHOSPHATE MINING COMPANY, LIMITED.

BEAUFORT, S. C., *October* 24, 1888.

DEAR SIR: Referring to the examination now being made by the officer of the United States Engineer Corps of the condition of Brickyard Creek, and looking to the improvement of the channel of this stream, I beg to call your attention to the importance of this subject, and to submit some figures showing the amount of tonnage per annum passing through this water-way from this company. I also have to request you, as the Representative of this district, to urge upon Congress the importance of the work and the necessity of an early appropriation to enable the officers of the Government to give us a channel of at least 7 feet at low water through this creek from Coosaw River to Beaufort River.

As you are aware, we have been mining phosphate rock in Morgan, Bull, and Coosaw rivers for the past three years, and intend to continue mining in these streams. To get this rock to our works it is necessary to tow it via Coosaw River, Brickyard Creek, Beaufort River, and Battery Creek to our works, and our tugs and lighters are constantly passing to and fro through Brickyard Creek. Our tugs draw fully 10 feet of water, and we are in consequence prevented from passing through this creek

except at the top of high water, and in case of a strong northwest or west wind blowing are sometimes unable to pass through even then. In case of accident or break down of a dredge, it is necessary to bring it through this creek to get it to our works for repair, and this is attended with considerable danger, in consequence of the narrow and tortuous channel and the very shallow spots therein.

In the course of the year we have lighters passing through this creek of an average tonnage of at least 80,000 tons, valued at $480,000.

Tug *Bristol*, 106 feet long, draught 10 feet 6 inches, making daily trips, value $30,000.

Tug *Kinkora*, 70 feet long, draught 9 feet 6 inches, perhaps three times a week, value $12,000.

Dredge *John Kennedy*, 140 feet long, 38 feet beam, and draught of 8 feet whenever necessary, value $130,000.

We sincerely trust that you will be able to secure this much needed improvement.

Yours, truly,

PHOSPHATE MINING CO., LIMITED.
F. BROTHERHOOD, *Suptg.*

Col. WM. ELLIOTT,
Member Congress Seventh District, South Carolina.

N 17.

PRELIMINARY EXAMINATION OF OWENDAW AND WANDO RIVERS AND OTHER WATERS AND WATER ROUTES CONNECTING BULL'S BAY AND THE HARBOR OF CHARLESTON, SOUTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
Charleston, S. C., December 7, 1888.

GENERAL: I have the honor to submit the following report of a personal examination made in accordance with the following clause of the river and harbor act of August 11, 1888.

SECTION 13. That the Secretary of War is hereby directed, at his discretion, to cause examinations or surveys, or both, to be made, and the cost of improvement to be estimated at the following localities, to wit: In the States of—

* * * * * * *

SOUTH CAROLINA.

* * * * * * *

Owendaw and Wando rivers and other waters and water routes connecting Bull's Bay and the harbor of Charleston.

From Bull's Bay there is a good water route up Harbor River and Owendaw Creek to a point about 5 miles below Owendaw Bridge. From this point the creek gradually diminishes in size, and is very crooked. Some of the high land adjoining is higher than generally exists in these coast lands. Trees falling from these banks have deposited a great many snags in the creek. Small vessels used for transporting wood, turpentine, rosin, etc., go up as far as the bridge, but as the volume of this business is small it is only occasionally.

Above Owendaw Bridge the creek continues about the same size until Steed's Creek comes in from the northeast. This is probably the larger branch of the two, and brings in from Hell Hole and Wambaw swamps most of the fresh water that Owendaw discharges. The other branch is, however, the only possible route for a canal to Wando River.

Less than a mile above, the tidal portion of the branch practically ends. It becomes a mere brook with considerable slope, draining a small swamp inland. Several small ditches only, 2 or 3 feet wide at the bottom, which are said to drain former rice lands lying between the Owendaw and Wando rivers, discharge into this brook. These ditches

pass through a plantation known as Rice Hope and part of another known as Withewood. They are probably 2 or 3 miles long.

I personally examined only about 1 mile of these ditches, which was sufficient to convince me that they were all so small as to have no practical bearing on the selection of a route. The examination from this side was stopped about 3 miles above Owendaw Bridge.

The land along the brook and ditches is comparatively high, and the divide between the two creeks is on the Withewood plantation. From this plantation and connecting with the ditches already described there is another system of ditches or drains discharging into Wando River through a large rice "canal" and Ward's Creek. I examined this canal, which is hardly worthy of being dignified with the name. It is practically a ditch running into Ward's Creek about 1 mile above Ward's Bridge. Most of it goes dry at low water.

Ward's Creek is not large at the bridge, but widens gradually towards Guerin's Creek, where it is quite wide. The two form Wando River, which is a fine, bold stream all the way to Charleston.

To establish a route up Owendaw and across the divide to Wando would require the cutting off of a number of bends in Owendaw, widening and deepening this creek for 5 miles; cutting a canal about 7 miles long through high land, in places thickly wooded; and considerable dredging and straightening in Ward's Creek. This would necessitate at least 4,000,000 cubic yards of excavation to give a practicable 6-foot channel at low water. Some cut-off dams and some bank protection would be needed. The cost of the excavation alone would exceed $1,000,000.

I do not consider it the best route. It was suggested by Capt. W. H. Bixby, Corps of Engineers, United States Army, as a means of entirely avoiding Bull's Bay in the inland passage between the Santee River and Charleston. He proposed to connect Santee River and Bull's Bay by a system of creeks and cuts ending in Long Creek, which enters Bull's Bay at the mouth of Harbor River.

Bull's Bay with an entrance 6 miles across is navigable only at high water, being obstructed by shoals. At times it is so rough that no boat would dare cross it even at high water. Any convenient and safe inland route must therefore pass entirely around it, as Captain Bixby reports. This can be done without cutting through the high land between Owendaw and Wando rivers, and for less than half the cost.

The route suggested is as follows:

Up Harbor River and Owendaw Creek about 3 miles; then a cut across the marsh for about 800 feet into Graham's Creek; follow this creek, cutting off one sharp bend, to within one-half mile of its mouth; thence cut through marsh about 1½ miles to Salt Pond Creek; follow this for about one-half mile, and cut for one-half mile through marsh to Belvedere Creek, following a small creek part of the way; follow Belvedere Creek to its mouth; thence cut across marsh one-quarter mile to Venderhorst Creek; follow this till it bends northwest and cut through marsh about one-third of a mile to Van Ross Creek; follow its western arm for one-half mile and cut across marsh two-thirds of a mile to Sewee Creek; follow Sewee Creek for three-quarters of a mile, and thence cut through marsh along the edge of Sewee Bay to the northern arm of Bull Creek; follow this one-half mile down to a point in the present island route from Bull's Bay to Charleston Harbor.

From this point to Charleston Harbor there is a continuous inland passage which, however, can be used only by a very small class of ves-

sels on account of three very narrow and shallow places. These are Bull Narrows, Meeting Reach, and the creek back of Sullivan's Island.

Bull Narrows is northwest of Bull's Island and connects Bull Creek with Price's Creek. It is very narrow and crooked and should be widened and straightened as well as deepened.

Meeting Reach is back of Long Island, and connects Morgan Creek, with Breach Inlet. It is very narrow, and goes dry at low water.

The creek back of Sullivan's Island has no name. Its western part is narrow and crooked. It should be widened and straightened and deepened, especially at a point called Spanish Fort about 1 mile from its western end.

Besides these there are shallow places in Santee Pass, Bullyard Sound, and in the cove back of Sullivan's Island.

To avoid Bullyard Sound in a manner similar to that advised for Sewee Bay seems desirable, as a channel dredged through this broad expanse of water would shoal at once. The cut would be about 1½ miles long.

The cost of this entire improvement, including necessary cut-off dams, etc., would not greatly exceed $500,000.

It might be made for $400,000 by passing across a comparatively deep part of Bull's Bay from Belvedere Creek to Bull's Harbor.

In easterly storms, however, this portion of Bull's Bay is very rough. I do not think this modification of the proposed route desirable.

The following additional facts have direct bearing on the choice of route:

From the mouth of Harbor River to Charleston is about 40 miles by either route. I see no reason to think that the cost for maintenance would be more in the one case than in the other. The marsh route is better for sailing-craft, as they would get better winds. The country through which the Owendaw and Wando Canal would pass is not very rich or productive. The marsh route would furnish an outlet for part of its products, but little longer and less convenient than the other; the rest would come down Ward's Creek and Wando River as now.

The business through the proposed route is at present small, as the passage is so difficult. It is, however, a very important link in the chain of inland waters, which is now practically interrupted between Georgetown and Charleston on account of shoal places in an otherwise continuous route. The complete opening up of this passage has great and evident value in a military point of view, and would accommodate a large amount of business that now passes outside in steamers ill-fitted for such work, and which are often weather-bound, or if caught in storms have to run into Bull's Bay and wait. They run up the Waccamaw River for many miles, and up the Santee and Congaree rivers as far as Columbia, and as soon as the railroad bridges are removed will also run on the Wateree River. The requirements of this river traffic prevent them from having sufficient draught to be in any sense safe craft to run outside, as they are now forced to do.

The statistics of this steamer business are given in the appendix to this report.

The Bull's Bay Oyster Company now have over 30,000 bushels of oysters planted in Bull's Bay and the creeks in the vicinity, and are constantly planting more. They expect to market 10,000 bushels of oysters, worth $7,500, this year. In addition to this they claim to do a business of $3,000 in terrapins, general freight, towage, etc. Their steamer is small, and generally uses the inside passage. Some wood and considerable naval stores and rice are brought to Charleston over this route in small sail-boats.

There is considerable timber, among other kinds much valuable cypress, on the headquarters of Owendaw Creek. Much of this would probably find its way to market in case the improvement was made.

If the recommendations of Capt. W. H. Bixby, Corps of Engineers, relative to improving Alligator River and other waters connecting Santee and Bull's Bay are carried out, the immense amount of timber on Santee River, which is as yet scarcely touched for want of a route to market, would be made available, and would come here in large quantities as soon as the route from Bull's Bay to Charleston was opened.

In estimating the business of the route it is fair to consider also a class of small coasters which bring rice and naval stores from North Carolina and South Carolina to Charleston. These now come outside, but, like the steamers, are frequently weather-bound.

Neither these vessels nor the steamers would derive the full benefit of the proposed route unless there were a continuous inland passage suitable for them from Winyaw Bay to Charleston. Sometimes under stress of weather they might make a harbor at Bull's and come on without stopping to Charleston, even if the part of the route covered by the present examination was all that was completed.

As a link in the chain of inland navigation from Winyaw Bay to Charleston, Savannah, and Florida cities, and thus an important adjunct to the coast defense in time of war and channel of commerce in time of peace, I consider this route worthy of improvement, and recommend that the sum of $2,000 be allotted for a survey of the marsh route, to enable me to make an exact estimate and well-considered project of improvement.

Very respectfully, your obedient servant,

FREDERIC V. ABBOT,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

LETTER OF MR. WILLIAM P. HOLMES, AGENT OF THE SOUTH CAROLINA STEAM-BOAT COMPANY.

OFFICE OF SOUTH CAROLINA STEAM-BOAT COMPANY,
Charleston, S. C., December 7, 1888.

DEAR SIR: The business for the past year between the Santee and Congaree rivers and Charleston, via Alligator River and other waters connecting Santee River and Bull's Bay, South Carolina, has been carried on by three steamers, their united tonnage being 1,025 tons.

The steamers during said period brought to Charleston—

Cotton, 9,158 bales, valued at about	$457,900
Turpentine spirits, 2,522 casks, valued at about	47,500
Rosin, 16,060 barrels, valued at about	48,180
Oak staves, 13,982, valued at about	8,400
Cypress shingles, 285,750, valued at about	3,480
Cross ties, 11,500, valued at about	3,450
Ash block, 498 cords, valued at about	3,000
Sundries, 1,130 packages, valued at about	6,000
And carried to the said river—	
General merchandise, 7,285 tons, valued at about	430,000

Very respectfully,

WM. P. HOLMES,
Agent.

Capt. FREDERIC V. ABBOT,
Corps of Engineers, U. S. A.

[From the above letter of Mr. Holmes it will be seen that the aggregate receipts at Charleston are valued at $577,910, and the total traffic at $1,007,910, *via* this line of steamers.]

SURVEY OF OWENDAW AND WANDO RIVERS AND OTHER WATERS AND WATER ROUTES CONNECTING BULL'S BAY AND THE HARBOR OF CHARLESTON, SOUTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
Charleston, S. C., December 20, 1889.

GENERAL: I have the honor to submit the following report of a survey made in accordance with the following clause of the river and harbor act of August 11, 1888:

SEC. 13. That the Secretary of War is hereby directed, at his discretion, to cause examinations or surveys, or both, to be made, and the cost of improvement to be estimated at the following localities, to wit: in the States of

* * * * * * *

SOUTH CAROLINA

* * * * * * *

Owendaw and Wando rivers and other waters and water-routes connecting Bull's Bay and the harbor of Charleston.

A good description of the Owendaw and Wando route was given in my report of December 7, 1888. To afford a reliable basis for an estimate of cost a stadia and level line was run from Wando Bridge to Owendaw Bridge through the lowest-lying intervening lands, following as far as practicable existing water courses. The smallest channel that would be of real benefit to commerce here is 75 feet bottom width, with 6 feet depth at low tide. Its position is shown on the accompanying map.

The material to be removed is of three classes: First, in Owendaw and Ward's Creeks marsh, which will cost 35 cents per cubic yard measured in place; second, cypress swamp, which experience shows can be cut through at 50 cents a cubic yard in place, including removing trees, etc.; third, rice lands, with probably buried cyprus stumps, which it is unsafe to estimate at less than 40 cents a cubic yard in place.

The following estimate is based on the survey and these prices:

ESTIMATE.

Owendaw and Wando route:	
Removing 425,000 cubic yards material from Ward's Creek at 35 cents per cubic yard	$148,750
Removing 816,000 cubic yards material through woods and swamp at 50 cents per cubic yard	408,000
Removing 863,000 cubic yards material in the rice fields of the Withewood plantation at 40 cents per cubic yard	345,200
Removing 573,000 cubic yards material in woods and swamp between Withewood plantation and Owendaw Creek at 50 cents per cubic yard	286,500
Removing 550,000 cubic yards material from Owendaw Creek at 35 cents per cubic yard	192,500
	1,380,950
Add about 10 per cent. for contingencies	119,050
Total	1,500,000

The estimate is based on prices which could be obtained if funds were provided at a rate of $500,000 a year, so that plant once at work could be kept continuously busy. Small appropriations would easily double the cost.

There is but one other inland water-route between Bull's Bay and Charleston; that in rear of the Sea Islands. This has been carefully surveyed with stadia and sounding line. The route laid down in the preliminary report of December 7, 1888, was found to be practically the best, and, as shown on the accompanying map, has been followed with but slight changes.

It is at all points sufficiently inland to be safe from injury from wearing away of the beaches, and to be out of range from hostile ships lying off the coast. The dredging is all simple marsh, which can be dredged at 35 cents per cubic yard. To provide a clear low-water channel 6 feet deep with 75 feet bottom width to connect at Long Creek with route proposed by Capt. W. H. Bixby, to connect Santee River with Bull's Bay the following quantities of material must be removed:

ESTIMATE.

Sea Island route:	
Sullivan's Island Cove, 30,000 cubic yards at 35 cents	$10,500
Sullivan's Island Narrows, 130,000 cubic yards at 35 cents	45,500
Long Island Creek and Meeting Reach, 330,000 cubic yards at 35 cents	115,500
Bull Yard Sound, 250,000 cubic yards at 35 cents	87,500
Santee Pass, 90,000 cubic yards at 35 cents	31,500
Bull Narrows, 140,000 cubic yards at 35 cents	49,000
Bull Creek to Long Creek, 990,000 cubic yards at 35 cents	346,500
Total for excavation	686,000
Add about 10 per cent. for contingencies	64,000
Total cost	750,000

This estimate is based on annual appropriations of $200,000. Less amounts will increase the ultimate cost.

The commerce that would naturally use either of these routes amounts to about $1,000,000 a year (see statistics appended to report of December 7, 1888). The Sea Island route costs the less; as it consists of a number of isolated places to be dredged a number of machines could work simultaneously, and the work thus be done rapidly if sufficient money was provided; also, as soon as any locality was improved, benefit therefrom would result. With the Owendaw-Wando route no benefit results until the cut is made all the way through, and work with dredges can only be done at the two ends. If intermediate work was attempted it would have to be done by hand or with dredges put together in the summit swamp.

I regard the Sea Island route as worthy of improvement by the United States. Two hundred thousand dollars a year could be advantageously expended on this work.

The survey of the Sea Island route was made by Mr. R. G. Thomas, assistant engineer; the Owendaw-Wando survey by Mr. James P. Allen, assistant engineer. Much credit is due both these gentlemen for the efficient manner in which the work was done and the large amount of valuable imformation obtained with the small amount available.

Very respectfully, your obedient servant,

FREDERIC V. ABBOT,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

ERRATA IN LIEUTENANT CARTER'S ANNUAL REPORT FOR 1890.

Page 1246.—Line 11 from bottom, no full stop after 1886.
Page 1246.—Line 11 from bottom, read a instead of A.
Page 1246.—Line 2 from bottom, insert comma after word "Point."
Page 1248.—Line 30 from bottom, read 900 instead of 90.
Page 1256.—Total for dredging $31,551.0 instead of 31,551.2.
Page 1256.—Value of upland receipts $37,878,926 instead of $37,828,926.
Page 1256.—Total value of cotton receipts $40,537,041 instead of $40,478,041.
Page 1256.—Value of upland exported $37,808,533 instead of $7,808,533.
Page 1257.—Tonnage arrived coastwise in 1879 411,794 instead of 414,794.
Page 1257.—Total tonnage arrived in 1885 661,989 instead of 668,989.
Page 1257.—Number of crew cleared, 1877, 2,589 instead of 2,489.
Page 1257.—Number of foreign vessels cleared, 1889, 309 instead of 307.
Page 1259.—Line 15 from bottom, read by the flood instead of the flood.
Page 1260.—Line 3 from bottom, read surface instead of service.
Page 1269.—Line 17 from top, read Back River instead of Bank River.
Page 1270.—Lines 19 and 20 from top, read easterly or westerly gales instead of easterly gales.
Page 1271.—Lines 27 and 28 from bottom, read that point instead of the point.
Page 1275.—For Meter A, read a equals 3.720 instead of a equals 3.730.
Page 1276.—Line 26 from bottom, read R instead of r.
Page 1276.—Lines 10 and 16 from bottom, read $V\frac{D}{2}$ instead of V_2^D.
Page 1276.—Line 7 from bottom, read d_m instead of D_m.
Page 1276.—Line 3 from bottom, read $C\frac{D}{2}$ instead of C_2^D.
Page 1276.—Line 29 from bottom, read average area instead of average.
Page 1277.—Line 7 from bottom, read divided by instead of divided.
Page 1277.—Line 7 from bottom, read correction instead of corrections.
Page 1278.—Line 15 from bottom at line E, read one-fifth instead of one fifty.
Page 1279.—Lines 13, 16, and 17 from bottom, read evaporation and absorption instead of evaporations and absorptions.
Page 1279.—Line 6 from bottom, leave out in.
Page 1281.—Line 11 from bottom, read 82,629,100 instead of 32,629,100.
Page 1282.—Line 22 from bottom, read lines *A* and *C* instead of lines *H* and *C*.
Page 1282.—Line 8 from bottom, read 395,200,400 instead of 295,200,400.
Page 1283.—Line 25 from bottom, read 85,500,000 instead of 35,500,000.
Page 1286.—Line 4 from bottom, read fact instead of facts.
Page 1289.—Line B, Ebb, vertical 6, read 2.93 instead of 3.93.
Page 1290.—Line D, Ebb, vertical 7, V_m, read 1.90 instead of 2.90.
Page 1290.—Line D, Flood, vertical 8, read 1.296 instead of 12.69.
Page 1293.—In table of comparative data, cross-section 11, read 990 instead of 900.
Page 1294.—Line 33 from bottom, read 10 and 11 instead of 10 and 12.
Page 1294.—Line 31 from bottom, read v equal 1.85 instead of v equal 1.05.
Page 1294.—Line 11 from bottom, read $\frac{a_e}{\text{width}}$ instead of $\frac{a}{\text{width}}$.
Page 1295.—Line 22 from bottom, read 19.4 instead of 10.4.
Page 1298.—Line 6 from bottom, read 1.78 instead of 1.88.
Page 1300.—Line 27 from bottom, read 791,851,518 instead of 791-751,518.
Page 1301.—Line 4 from bottom, read 1.68×1.25 instead of 1.68+1.25.
Page 1301.—Bottom line, read 1.80 instead of 180.
Page 1302.—Line 28 from top, read such opening instead of each opening.

Page 1307.—Line F, Flood, vertical 6, May 20, read 5*h* 02*m* instead of 4*h* 02*m*.
Page 1308.—Line A, Ebb, vertical 10, read 0.90 instead of 0.70.
Page 1308.—Line B, Ebb, vertical 5, read 1615 instead of 1618.
Page 1309.—Line A, Flood, column 5, read rise on date instead of fall on date.
Page 1309.—Line B, Flood, sum, read 10,427 instead of 10,437.
Page 1310.—Line D, vertical 7, real 7*h* 32*m* instead of 7*h* 33*m*.
Page 1311.—Line C, Flood, column 5, read rise on date instead of fall on date.
Page 1311.—Line D, Flood, sum, read 428,193,437 instead of 438,193,437.
Page 1313.—Line E, Flood, column 5, read rise on date instead of fall on date.
Page 1315.—Line G, Flood, column 5, read rise on date instead of fall on date.
Page 1316.—Section 30, read 35,920 instead of 45,920.
Page 1316.—Bottom line, read there are instead of there is.
Page 1320.—Line H, Ebb, vertical 2, read 11,168 instead of 11,186.
Page 1320.—Line H, Ebb, vertical 5, read 41 *Min.* instead of 47 *Min.*
Page 1320.—Line H, Ebb, read correction for instead of corrected for, and corrected ebb flow instead of corrected flood flow.
Page 1320.—Line H, corrected ebb flow, read 1,669,617,114 instead of 1,669,671,114.
Page 1321.—Line H, Flood, read correction for instead of corrected for and corrected flood flow instead of corrected ebb flow.
Page 1321.—Line H, Flood, column 5, read rise on date instead of fall on date.
Page 1323.—Line K, Flood, column 5, read rise on date instead of fall on date.
Page 1329.—Heading in first table, read Cubic feet per second instead of Feet per second.
Page 1329.—Table of works of improvement, obstruction No. 1, insert the word constructed after the words shore protection.
Page 1329.—Table of works of improvement, obstruction No. 3, read $18,600.00 instead of $18,000.00.
Page 1330.—Table of works of improvement, obstruction No. 17, read point should be eased off instead of cased off.
Page 1330.—Table of works of improvement, transpose Reezer Creek from obstruction No. 40 to No. 39.
Page 1332.—Line 18 from top, read 1889 instead of 1890.
Page 1334.—Line 27 from top, read sights instead of sites.
Page 1334.—Line 4 from bottom, read subtracting instead of substracting.
Page 1335.—Line 9 from top, read 119.30 instead of 110.30.
Page 1335.—Line 14 from bottom, insert level after wye.
Page 1337.—Line 2 from bottom, read graphically instead of geographically.
Page 1338.—Line 13 from top, read from the time instead of from time.
Page 1338.—Line 3 from bottom, gauge at Augusta on October 27, read 7.8 instead of 6.8.
Page 1346.—Line 33 from top, low water at 70 miles, read 7.8 instead of 7.0.
Page 1346.—Line 4 from bottom, read 1.08 instead of 4.08.
Page 1349.—Line 3 from bottom, read two or three instead of two.
Page 1353.—Line 4 from bottom, read below low water instead of below water.
Page 1357.—Line 35 from top, read their instead of the.
Page 1359.—Heading in table, read Through freights instead of Rough freights.
Page 1359.—Value of cotton, local freight, read 583,180 instead of 593,180.
Page 1359.—Total value of naval stores, read 210,020 instead of 21,029.
Page 1359.—Tons of cordwood, local freight, read 2,560 instead of 3,560.
Page 1365.—Distance of Flat Ditch Point, read 29½ instead of 23½.
Page 1365.—Distance of King Creek 115½ instead of 115¼.
Page 1372.—Line 13 from top, insert as before determined.
Page 1374.—Line 17 from top, read Hell's instead of Holl's.
Page 1375.—Line 15 from top, read bearing instead of boating.
Page 1375.—Line 21 from top, read sketch instead of stretch.
Page 1377.—To title Removal of snags add etc.
Page 1378.—Line 36 from bottom, read distances instead of distance.
Page 1378.—Line 25 from bottom, read 1883 instead of 1885.

Page 1378.—Lines 15 and 16 from bottom, read Beard's intead of Board's.
Page 1379.—Line 12 from top, read 86 instead of 36.
Page 1379.—Line 14 from top, read 89 instead of 39.
Page 1381.—Read Beard's instead of Board's.
Page 1381.—Cost of improvement at Beard's Bluff, read 7,000 instead of 7,600.
Page 1381.—Distance of Weeping Willow Crossing, read 128 instead of 123.
Page 1381.—Engineering and contingencies, read 16,777.50 instead of 16,777.05.
Page 1381.—Aggregate, read 128,627.50 instead of 128,627.05.
Page 1383.—Heading in first table, insert and after shipping.
Page 1383.—Fourth column, first table, strike out dollar mark ($).
Page 1383.—Value of wild land, Glynn County, read 165,994 instead of 265,994.
Page 1383.—Aggregate value of property in 1887, read 8,766,022 instead of 7,766,022.
Page 1384.—Line 11 from bottom, read 21,217,800 instead of 21,780,000.
Page 1384.—Line 10 from bottom, read 21,221,450 instead of 21,783,650.
Page 1384.—Line 9 from bottom, read 21,242,215 instead of 21,804,415.
Page 1385.—Total tonnage, City of Americus, read 6,880.5 instead of 8,256.6.
Page 1385.—Aggregate of total tonnage, read 48,323.9 instead of 49,700.00.
Page 1387.—Total number of vessels arrived in 1881, read 266 instead of 166.
Page 1394.—Distance of Rifle Cut, read 48½ instead of 43¼.
Page 1398.—Line 17 from top, read 1877 instead of 1887.
Page 1400.—Line 16 from top, read 83 instead of 38.
Page 1402.—Stumps below Lumpkins' Old Field, read 19 instead of 16.
Page 1402.—Overhanging trees below Lumpkins' Old Field, read 26 instead of 27.
Page 1404.—Line 18 from bottom, read 7.8 instead of 6.8.
Page 1406.—Line 6 from bottom, number of cross-ties, read 150,000 instead of 159,000.
Page 1408.—Line 22 from bottom, read lunitidal instead of semitidal.
Page 1409.—Line 10 from bottom, read Mean areas instead of Mean arears.
Page 1411.—Line 30 from top, read has had instead of had had.
Page 1412.—Line 27 from bottom, read bases instead of basess.
Page 1413.—Line 4 from bottom, read minutes instead of moments.
Page 1414.—Line 5 from top, read no instead of any.
Page 1415.—Line 35 from bottom, insert the word by before cut-off.
Page 1415.—Line 15 from bottom, read passed instead of placed.
Page 1427.—Line 9 from top, read unfavorable instead of favorable.
Page 1439.—Line 11 from bottom, put a comma after the word "railway," and add the words which refers to mean low water at Savannah.
Page 1528.—Line 18 from bottom, read river instead of water.
Page 1547.—Line 25 from top, read Leon street instead of Loon street.
Page 1548.—Line 4 from top, read Leon street instead of Loon street.
Page 1548.—Line 8 from top, read Leon street instead of Loon street.

APPENDIX O.

IMPROVEMENT OF RIVERS AND HARBORS IN GEORGIA AND OF CUMBERLAND SOUND, GEORGIA AND FLORIDA.

REPORT OF LIEUTENANT O. M. CARTER, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1890, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

IMPROVEMENTS.

1. Savannah Harbor and River, Georgia.
2. Savannah River, Georgia.
3. Savannah River above Augusta, Georgia.
4. Romley Marsh, Georgia.
5. Altamaha River, Georgia.
6. Oconee River, Georgia.
7. Ocmulgee River, Georgia.
8. Brunswick Harbor, Georgia.
9. Jekyl Creek, Georgia.
10. Cumberland Sound, Georgia and Florida.

EXAMINATIONS AND SURVEYS.

11. Oconee River, Georgia.
12. Ocmulgee River, Georgia.
13. Savannah River (above Augusta), Georgia.

HARBOR LINES.

14. Establishment of Harbor-Lines at Fernandina Harbor, Georgia.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., July 3, 1890.

GENERAL: I have the honor to transmit herewith my annual report for the fiscal year ending June 30, 1890, upon the works of river and harbor improvement then in my charge.

Very respectfully, your obedient servant,

O. M. CARTER,
First Lieut. Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

O 1.

IMPROVEMENT OF SAVANNAH RIVER AND HARBOR, GEORGIA.

Operations for improving this harbor and river have been carried on in accordance with a project of improvement submitted to the Chief of Engineers by General Gillmore, the officer then in charge, dated Janu-

ary 16, 1882, and printed as part of Appendix J 4, Annual Report of the Chief of Engineers for 1882. This project is essentially an enlargement of two previous plans, one dated August 28, 1873, and printed as part of Appendix S 4, Annual Report of the Chief of Engineers for that year, and the other dated March 19, 1879, and printed as part of Appendix J 4, Annual Report of the Chief of Engineers for 1880. For a special history of past work, see pages 1012–1023, Annual Report of the Chief of Engineers for 1888.

ORIGINAL CONDITION.

In 1873, before the work of improvement upon the present plan was inaugurated, the usual draught of vessels navigating the river at high water was 14.5 feet. The mean rise and fall of the tide was about 6.5 feet at the city of Savannah, and 7 feet at the mouth of the river.

PLAN OF IMPROVEMENT.

The plan of improvement under which operations have been carried on up to date provides for the establishment of a channel from Tybee Roads to the city of Savannah, practicable at high tide for vessels drawing 22 feet of water, and the widening of the channel of the river opposite the city to 600 feet, of uniform depth with the balance of the channel. The following comprise the main features of the enlarged project:

(1) To construct a closing dam at Cross Tides, above the city of Savannah.

(2) To enlarge the water-way between Cross Tides and the city.

(3) To regulate the width of the river along the city front by enlarging the water-way at certain points, and by contracting it by wing-dams at Garden Bank where the widths are excessive.

(4) To construct a training-wall, extending eastward from Fig Island.

(5) To construct a low dam across the upper end of the South Channel.

(6) To improve the north channel of the river, closing the channels between Barnwell Islands and those connecting the north and south channels, and contracting the river by wing-dams at various points between the head of the Elba Island and Fort Pulaski.

(7) To protect the banks at various points along the river and to dredge upon all the shoals between the city and the sea.

The cost of the original project of 1873 was estimated at $482,000, and as amended and enlarged at $1,212,000.

A mean high-water depth of 22 feet being entirely insufficient to accommodate the large and rapidly growing commerce upon the Savannah River, in 1887, in obedience to an act of Congress approved August 5, 1886. A preliminary project with estimates of cost of improvement for obtaining 28 feet of water from the city of Savannah to the sea was submitted and is printed on pages 1056–1073, Annual Report of the Chief of Engineers for 1888.

The principal features of the project are:

(1) To enlarge Drakie's Cut to a width of 200 feet.

(2) To enlarge the channel south of King's Island to a width of 400 feet and to close the Cross Tides.

(3) To build a training-wall from the lower end of Marsh Island to Kinsey's Point to enlarge the river at the city to a width of 600 feet by cutting off a portion of Hutchinson's Island, and to connect the ends of

the Garden Bank wing-dams by a training-wall extending from the old dry-dock to a point above Fig Island Light.

(4) To close the south channel below the mouth of St. Augustine Creek; at the same time throwing a low sill-dam across the creek.

(5) To connect the ends of the wing-dams between the head of Elba Island and the Oyster Beds by training-walls, and to construct two training-walls, extending about 3 miles eastward from the Oyster Beds, for the improvement of the channel across Tybee Knoll.

(6) To construct a detached breakwater, rising to 2 feet above mean high water, and extending from shoal water between the mouths of Calibogue Sound and New River in a southeasterly direction to deep water across the bar; to construct a south jetty, if necessary, springing from the north end of Tybee Island and extending in a northeasterly direction to deep water across the bar. This jetty to be at high water at its inner end sloping down to half-tide at 500 feet out, and retaining that height to the inner 18-foot curve of the bar; beyond that point to be an apron course only. Width between the jetties at outer 21-foot curve to be about 2,500 feet; at the inner 18-foot curve about 5,500 feet.

(7) To dredge a channel at least 300 feet wide and 28 deep at mean high water from the city to the sea, the dredged material to be deposited on banks or behind training-walls.

(8) To construct shore protections at various points.

The cost of the project is estimated at $6,660,000.

Inasmuch as the survey of 1887 revealed a depth on the outer bar of 26 feet at mean high water, to secure a channel of that depth from the city to the sea, the improvement of the ocean bar will not be necessary unless future shoaling should take place there.

A project for obtaining a channel depth of 26 feet at mean high water from the city of Savannah to Tybee Roads is transmitted herewith, and for detailed information reference is respectfully made to this.

The cost of this improvement is estimated in round numbers at $3,500,000, provided funds are regularly and adequately supplied.

Prior to 1826 an expenditure of about $100,000, raised by a tax upon shipping entering the harbor, was made under the direction of the commissioners of pilotage in clearing the river of wrecks, and in otherwise improving its condition, and between 1867 and 1871 an expenditure of $157,000 was made by the city of Savannah in dredging on the shoals between Cross Tides and the sea. From 1826, the date of the first appropriation made by the United States for the river, up to the date of beginning operations according to the 22-foot plan of improvement, appropriations aggregating $667,096.64 were made by Congress for the work.

Since the adoption of the plan of improvement aiming at securing 22 feet of water, eleven appropriations have been made for the work, aggregating $1,212,000.

SUMMARY OF OPERATIONS PRIOR TO JULY 1, 1889.

In 1872 the United States Engineer Department resumed charge of the improvement of the river and harbor, and from that time up to July 1, 1874, since which date operations have been carried on in accordance with the 22-foot plan of improvement previously described, there were removed from the channel 6 vessels, 16 cribs, and 1 sunken lighter, besides 166,498 cubic yards of material, dredged from the wrecks,

the shoals abreast of Elba Island and at the Oyster Beds, and from Tybee Knoll.

Under the 22-foot project the following work has been accomplished:

At Cross Tides a dam has been constructed, extending from the rice dike on Argyle Island to that on Hutchinson's Island, with the object of diverting a larger volume of water at ebb tide into the Front River. This dam was originally designed to be a pile structure, and was begun in 1876. During the next year it was so much injured by a freshet that work upon it was suspended. In December, 1878, the present dam was begun. It is composed of log and brush mattresses, and brush fascines loaded with riprap stone, and is located 273 feet above the abandoned pile structure.

As soon as the dam was brought up above the level of mean low water considerable settlement occurred, due to scour caused by the ebb tide overpour. To prevent further scour an apron of log mattresses was placed along its down-stream face, and the dam was raised in 1885 with brush fascines and stone to the level of high water by building on the up-stream side of the crest, utilizing the old structure as an additional apron.

Since that time further settlement has occurred, and the work has also been damaged by fishermen and other parties, who throw large quantities of stone off the dam to open a short water route from Back River to the city of Savannah.

About 70 linear feet of the old King's Island Jetty, near Cross Tides, was removed in 1880–'81 to facilitate the flow of water into Front River.

Three wing-dams were constructed in 1882–'83 for the improvement of the Garden Bank Shoal in front of the city. They spring from Fig Island, and contract the water-way, which was formerly from 90 to 1,050 feet in width, to about 560 feet. A short spur-jetty was built in 1883 about 800 feet above the lower end of Fig Island to regulate the ebb flow from Front River into the Wrecks Channel.

To properly confine the ebb currents in the Wrecks Channel a training-wall, rising to mean high water, was built for a length of about 6,750 feet down stream from a point a little above the lower end of Fig Island, with which it is connected by a return work 160 feet in length.

This training-wall, begun in 1881, and extended and raised at intervals since then, runs about parallel to the right bank of the river, and is provided on the channel side with 11 short spurs, placed at right angles to the axis of the channel, which has a low-water width increasing from 680 feet at the upper end to 880 feet at the lower.

Two dams, numbered 5 and 11½, respectively, and designed to increase the flow of water in the main channel, were built in 1883 to close lateral channels on either side of Barnwell's Island, opposite Fort Oglethorpe.

A low sill-dam, designed to increase the ebb flow in the north channel, was built in 1881 across the south channel a short distance below the head of Elba Island.

A wing-dam, numbered 15, was built in 1883 for the improvement of the channel at the obstructions. It extends eastward from Barnwell's Island No. 3, and contracts the water-way, which was formerly about 1,950 feet in width, to about 1,000 feet.

Three pairs of wing-dams have been built for the improvement of the crossing at the Upper Flats. Those numbered 4 and 23, built in 1883, constitute the upper pair, and are situated at the eastern end of Spirit Island. Those numbered 6 and 25, constituting the second pair, and those numbered 10 and 27, constituting the third pair, are situated at distances below the first of about 800 and 1,600 yards, respectively.

The original low-water width of the river at this crossing varied from

2,000 to 4,000 feet. It is reduced by these dams to 1,050 feet at the upper and to 1,200 feet at the lower pair. These dams rest with the inner ends of the respective pairs upon opposite banks of the river, with the exception of the one numbered 27, between whose inner end and the shore there is a gap of about 500 yards.

Three wing-dams have been built for the improvement of the crossing at the Lower Flats. At the upper end of this crossing dams numbered 14 and 29 were built in 1883–'85. They spring from opposite banks of the river, and contract the water-way from over 2,400 feet to 1,250 feet. At the lower end of this crossing a partially-completed dam, numbered 13, was built in 1883. It springs from Island 1 and 2, and leaves a water-way 1,250 feet in width between its outer end and the opposite shore of Jones Island.

The lateral channels at Philbrick's Cut, Big Gap, and Dutch Gap are closed by dams built in 1882.

Two pairs of wing-dams have been built for the improvement of the Long Island Crossing.

Dams numbered 26 and 33, constituting the upper pair, were built in 1885. They reduce the low-water width of the river from 3,100 to 1,300 feet. Dams numbered 28 and 35, constituting the lower pair, were built in 1886–'87, and reduce that width from 4,500 to 1,350 feet. The inner ends of these dams are connected with shore, with the exception of number 35, between whose inner end and the shore of Jones Island there is a gap of 500 feet.

To prevent the diversion of the ebb flow from the main ship-channel a dam numbered 31, and about 3,500 feet in length, was built in 1885, to close the old channel north of the Oyster Beds.

For the improvement of the channel across Tybee Knoll, a training-wall, extending from the Oyster Beds eastward a distance of 1,031 feet, was begun in January, 1889. Two courses were completed during the fiscal year.

All of the structures described are composed of log and brush mattresses, or brush fascines, or both, loaded with riprap stone. In their original construction and in the repairs which it has been necessary to execute up to July 1, 1889, there have been used 424,673.24 square yards of log and brush mattresses, 65,357.5 cubic yards of brush fascines, 91,773.24 cubic yards of riprap stone, and 283.3 cubic yards of shells, while 622 cubic yards of stone have been removed in repairing the Fig Island training-wall.

During this period the river channel was widened at the lower end of Fig Island, and more or less dredging was done upon the various shoals between Cross Tides and Tybee Knoll. Up to July 1, 1889, the total dredged material removed, consisting of sand, mud, and shells, amounted to 2,045,306.52 cubic yards.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

During the past fiscal year jetty work was continued under the existing contract with Mr. William T. Gaynor, operations being confined to the training-walls at Fig Island and at the Oyster Beds. The work at the Fig Island training-wall consisted of repairs in the execution of which 350 cubic yards of old riprap stone were handled, and 495.78 cubic yards of brush fascines, 5 cubic yards of oyster shells and 223.45 cubic yards of stone were used.

At the Oyster Bed training-wall 3,660.6 linear feet of log and brush mattresses, 35 feet in width, were placed in the third course, and the

entire crest of the training-wall lightly loaded with riprap stone. There were used 14,006.25 square yards of log and brush mattresses, 303.57 cubic yards of oyster shells and 3,350.89 cubic yards of stone. Operations were suspended on August 20, 1889, on account of the exhaustion of funds.

Dredging was carried on under the existing contract with Mr. P. Sanford Ross. The work which was suspended on June 3, 1889, was resumed on July 16, and completed on August 22, 1889. Operations were confined to the channel in the vicinity of the ocean steam-ship wharves and across the Garden Bank 9,384.3 cubic yards being dredged from the former and 10,038.5 cubic yards from the latter locality. Some shoaling having taken place during the year authority was sought and obtained for the hire of a dredge in open market, and 2,351.5 cubic yards were dredged from the Garden Bank, and 3,610.5 cubic yards from the channel near the foot of West Broad street between February 25 and March 10, 1890, and 6,166.2 cubic yards from the channel across the Upper Flats between April 15 and 30, 1890. All of this work was done by the Savannah Dredging Company at $18\frac{1}{2}$ cents per cubic yard, the price paid under the last contract.

The hydrographic survey of the river, referred to in my previous report, has been completed. The results are to be found in the appended report of Mr. E. A. Gieseler, assistant engineer, to which attention is invited and which I beg to submit entire as part of my own report.

During April and May an examination of the river was made from Cross Tides to Tybee Roads. There were taken 56,730 soundings, with 9,606 located positions. Velocity and discharge measurements were made near the Oyster Beds and on Tybee Knoll.

The office reductions have been completed and a report submitted.

CONDITION OF WORK JUNE 30, 1890.

Cross tides.—The condition of this dam is almost as described in my report for 1888. The general crest is now at an average height of about 1.5 feet above mean low water.

City of Savannah.—The cut dredged between the water-works and the ocean steam-ship wharves has disappeared, but there is a general deepening of about one-half of a foot over the entire shoal. The shoal in the vicinity of the upper rice mill has not re appeared, there being now a minimum channel depth of 15 feet at mean low water in this locality. Some shoaling has taken place at the Garden Bank, but there is still a practicable 15-foot low-water channel at this locality.

Wrecks channel.—The Fig Island training-wall is in good condition, no material settlement having taken place. There is a practicable 15 foot mean low-water channel through the Wrecks, but it is quite narrow at the lower end. Some dredging is needed at that point.

Obstructions.—Wing-dam 15 is in good condition. There is now a least channel depth of 15.5 feet at mean low water. A permanent removal of this shoal can not perhaps be expected until a deflecting jetty is built above the mouth of the south channel, or until this channel is obstructed or closed.

Upper Flats.—All of the wing-dams built for the improvement of this crossing are in good condition. Some dredging was done during the year between dams 10 and 27, and there is now a mean low-water depth of 15.5 feet in the channel at that locality.

Lower Flats.—All of the wing-dams in this locality are in good con-

dition. A shoaling of about 1 foot has taken place during the year, there being now a mean low-water depth of 14 feet across the shoal.

Long Island Crossing.—The wing-dams at this crossing are in good condition, and have accomplished the object for which they were constructed. There is now nowhere on this crossing a less depth than 15 feet at mean low water.

Oyster Beds.—Dam 31 has settled some, but has accomplished the object for which it was built. The channel at that point has been well maintained during the year.

Tybee Knoll.—There is now a channel across the inner end of the knoll 15 feet deep at mean low water. On the Venus Point ranges, near the lower end of the knoll, the channel depth is at present only 13 feet at mean low water. The Oyster Beds training-wall is in good condition, but operations were suspended on the third course on account of the exhaustion of funds.

Closing-dams.—All of the closing-dams upon the river, with the exception of those at Philbrick's Cut and Big Gap, are in good condition. Some breaks have taken place in the closing-dams at Philbrick's Cut and Big Gap, which when completed were at the level of mean high water. A great deal of stone is thrown off of those dams by negro fishermen to open a water-way through into the south channel, and these small gaps have rapidly enlarged under the influence of storms. All of the other closing-dams are in good order, although they have settled slightly in some cases.

COMMERCE AND NAVIGATION.

The improvement of the harbor of Savannah has led to a great and rapid increase in the commerce of the port. Existing railroads have extended their lines and made new connections, opening up a much larger territory for the trade of Savannah. A new road (the Savannah, Americus and Montgomery Railway) completed its line to Savannah in May last. Two other new roads to terminate at Savannah are in process of construction and others still are projected. One road increased its rolling-stock during the past year by 4,000 cars, to handle its increased traffic, and the increase has been proportional on other roads. Still much freight has been rejected and sent to northerly ports on account of the inability of those roads to handle all that offered. The systems now terminating in Savannah have more than 4,000 miles of track, exclusive of connecting lines. Another means of communication with the interior is the Savannah River, navigable as far as Augusta for boats drawing about 4 feet of water. These avenues of commerce bring to Savannah the cotton, lumber, naval stores, and farm products of large portions of the States of Georgia, South Carolina, Florida, Alabama, Mississippi, and Tennessee, as well as other classes of through freights from the North and West.

Regular lines of steamers have been established between this port and Boston, New York, Philadelphia, and Baltimore. A large fleet of coasting vessels is also engaged in the Savannah trade. About one-third of the exports are to foreign ports, and in this foreign trade is engaged a large number of foreign steamers and sailing vessels of great draught and tonnage.

Steam-ship lines.

Line.	Savannah to—	No. of steamers.	No. of voyages.	Tons freight.
Ocean Steam-ship Company	Boston	4	60	77,440
Ocean Steam-ship Company	New York and Philadelphia	10	230	411,654
Merchants and Miners' Transportation Company.	Baltimore	3	70	93,584
Total		17	360	582,678

Shipping and tonnage of the port of Savannah, June 1, 1889, to May 31, 1890, entering and outward bound.

	Steam.	Sail.	Total.	Tonnage.
American	758	570	1,328	1,363,880
Foreign	216	472	688	538,568
Aggregate	974	1,042	2,016	1,902,448

Vessels are now limited to a draught of about 21 feet. The three new railroads in process of construction, and the greater facilities for carrying freight adopted by existing roads, will bring to Savannah in the future a greatly increased volume of trade seeking an outlet to coastwise and foreign ports. Light draught-vessels will be unable to handle this trade economically. Past improvement has resulted in increasing the available depth at high water from about 15 feet to about 21 feet. As stated in last year's report, the annual saving of freight rates alone, due to this cause, amounts to more than the total sum of money expended by the United States upon the harbor since the close of the civil war. Rates of marine insurance have also been reduced. The increase in the value of exports since 1873, when works of improvement were begun under the existing project, is proportional to the cube of the increase in the depth of water during the same period. If the same proportion should hold till a depth of 26 feet is reached, the value of the exports alone would then be about $150,000,000.

MISCELLANEOUS.

The river is in fair condition, but work has not progressed satisfactorily, and its cost has been much increased by the irregular and inadequate appropriations. Future operations should be carried on simultaneously throughout the whole extent of the river, and to secure successful and permanent results, dredging should be accompanied or promptly followed by contracting works. To secure the fullest benefits from the improvements already executed, and in order that the future growth of the port may not be seriously retarded, it should be enabled to furnish an outlet for the rapidly growing commerce brought from the interior. It is proposed to expend any funds which may become available during the year in the construction of training-walls and in dredging, as provided for in the project for securing a depth of 26 feet at mean high water.

A vigorous and economical prosecution of the work will be possible only with regular and adequate appropriations. The insufficient and irregular appropriations of the past have rendered satisfactory progress

impossible, and have increased the cost of the work in some instances as much as 100 per cent. The sum asked for during the next fiscal year is $1,000,000. The most desirable and satisfactory results can not be obtained with an expenditure during the year of a less amount.

The work is located in the collection district of Savannah, Ga. Savannah is the port of entry. Amount of duties collected in 1889, $58,815.54. The nearest lighthouses are those upon the river, and Forts Oglethorpe and Pulaski are the nearest forts.

Since the works of improvement were commenced the following appropriations have been made:

By act of Congress approved—

June 23, 1874	$50,000
March 3, 1875	70,000
August 14, 1876	62,000
June 18, 1878	70,000
March 1, 1879	100,000
June 14, 1880	65,000
March 3, 1881	65,000
August 2, 1882	200,000
July 5, 1884	200,000
August 5, 1886	150,000
August 11, 1888	180,000
Total	1,212,000

The total expenditures to June 30, 1890, including all outstanding liabilities, were $1,208.122.39.

Money statement.

July 1, 1889, amount available		$41,335.45
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$37,300.40	
July 1, 1890, outstanding liabilities	157.44	
		37,457.84
July 1, 1890, balance available		3,877.61
Amount appropriated by act of September 19, 1890		350,000.00
Amount available for fiscal year ending June 30, 1891		353,877.61
Amount (estimated) required for completion of existing project		3,150,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		1,000,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. A. S. COOPER, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., June 30, 1890.

SIR: I have the honor to submit the following report of operations for the improvement of Savannah Harbor, Georgia, during the fiscal year ending June 30, 1890:

The jetty work under contract with Mr. William T. Gaynor, dated January 16, 1889, was completed August 20, 1890, being finished much sooner than was expected. The principal part of this work was done on the Oyster Bed training-wall, and consisted of log mats and riprap stone. Repairs to Fig Island Jetty, going on at the end of the last fiscal year, were completed in July, 1889.

Dredging was continued under contract with Mr. P. Sanford Ross, dated November 28, 1888, and completed August 22, 1889. Other dredging has been done by special contract with the Savannah Dredging Company, at places where shoals had formed after the regular contract dredging was done.

CROSS TIDES.

The only change since the last annual report in this locality worthy of note, is the scouring between King's Island and the Georgia shore. In some places as much as 15 feet of the high bank have been washed away. By a comparison of the United States Coast Survey of 1874 with the complete set of soundings taken this year, it will be seen that the channel between this island and both the Georgia and Hutchinson's Island shores has deepened from 5 to 10 feet. Continuing this comparison to Marsh Island, an average increase in depth of about 5 feet will be noted. The large amount of material scoured out of this part of the river since Cross Tides Dam was built was probably deposited on the shoal places lower down, Garden Bank and the Wrecks Channel probably receiving the greater portion. Should the upper part of the river be dredged out enough to accommodate the increased flow of water in Front River, the annual dredging at other points would be thus greatly diminished.

CENTRAL RAILROAD WHARF.

There is now no signs of the cut made last year between the Water Works and the Central Railroad wharves except a general deepening of about one-half of a foot all over the shoal. The water on this shoal now averages about 2 feet deeper than in 1874. The dredging done in the early part of this year just above the slip has not yet shoaled up materially.

UPPER RICE MILL.

Four small lumps having formed on this shoal they were dredged off in March, 1890, There is now a depth of 15 feet at mean low water over this shoal, being a decrease of 1 foot since last year.

GARDEN BANK.

The lump which had formed at the end of the last fiscal year on this shoal was removed in August, 1889. This lump having re-appeared in February, 1890, it was again removed. This same ridge is now forming again, and at the present time is fully halfway across the channel, and may cause serious trouble before the next appropriation becomes available. This shoal always first appears at or just below the barge office, and if not dredged away continues to grow down-stream until the lower cotton-press is reached, making a shoal of more than 1,000 feet in length.

WRECKS CHANNEL.

Fig Island Jetty is in good condition, no settlement having taken place except where new work was done. This, however, is slight and no more than was expected. One hole, about 15 feet wide and 3 feet deep, was made in the extension; cause not known. No change worthy of note in the 15-foot curve at the upper end of this channel has taken place since the last annual report. At the lower end of the Wrecks Channel, where the greater part of the dredging was done last year, some shoaling has taken place, but the 15-foot curves have not yet closed. This shoaling, and that in the past, would seem to indicate that the lower end of Fig Island Jetty has been located a little too far from the Georgia shore. If this is the case one or two short spurs would remedy this defect. The bank at the lower end of this channel has not advanced more than 20 feet during the last year, showing that the downward movement of this bar has about stopped.

OBSTRUCTIONS.

The channel on this shoal has held very well during the past year, there now being a depth of 15.5 feet at mean low water, a shoaling of about 0.3 of a foot since last reported. No work was done here during the year. Dam No. 15 is in good condition.

UPPER FLATS.

A shoal having again formed between Dam No. 27 and Dam No. 10, it was dredged out in April, 1890. There are now 15.5 feet at mean low water in this cut. The shoal at the upper end of the Upper Flats, mentioned in my last report, has disappeared without any dredging. All jetties here are in good condition.

LOWER FLATS.

No work was done on this shoal during the year. There are now 14 feet at mean low water here, a shoaling of 1 foot since last year. All jetties are in good condition.

LONG ISLAND CROSSING.

No change has taken place here, except a general deepening of about two-tenths of a foot over the whole crossing. All jetties are in good condition. Scouring to the amount of about 1 foot has taken place between Dam No. 33 and Jones's Island.

OYSTER BED SHOAL.

No change has taken place in Dam No. 31 during the past year. There is plenty of water in the channel here, but the turn is very sharp.

TYBEE KNOLL.

No change has taken place during the past year on the inner half of the Knoll. The lower end of the cut made last year has filled up, thus moving the inner 15-foot curve 1,000 feet toward Savannah. The outer 15-foot curve has also moved about 100 feet toward Savannah. The shoalest water on this part of the Knoll is 13 feet at mean low water, and the distance from the inner to the outer 15-foot curve is 3,900 feet.

CLOSING-DAMS.

There has been no change in these dams since my last report.

OYSTER BED TRAINING-WALL.

Work was stopped on this dam August 20, 1889. No damage has been done to the work since then by storms, and very little settlement has taken place.

The following table shows the work done during the year:

Jetty work.

Date.	Locality.	Stone.	Mattresses.	Shells.
1889.		*Cu. yds.*	*Sq. yds.*	*Cu. yds.*
July	Oyster Bed training-wall	2,538.24	14,006.25	303.57
August	....do	812.65	.....	.....
Total		3,350.89	14,006.25	303.57

Date.	Locality.	Shells.	Stone placed.	Fascines.	Stone moved.
1889.		*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*
July	Fig Island Jetty	.....	.....	495.78	350
August	.....do	5	223.45	.....	.....
Total		5	223.45	495.78	350

Dredging.

Date.	Where done.	Amount.
		Cu. yds.
July 16 to August 3, 1889	Ocean steam-ship wharves	9,384.3
August 5 to August 22, 1889	Garden Bank	10,038.5
February 25 to March —, 1890	do	2,351.5
March 3 to March 10, 1890	West Broad street	3,610.5
April 15 to April 30, 1890	Upper Flats	6,166.2
Total		31,551.2

Very respectfully, your obedient servant,

A. S. COOPER,
Assistant Engineer.

Lieut. O. M. CARTER,
Corps of Engineers, U. S. A.

COTTON STATISTICS OF THE PORT OF SAVANNAH, GEORGIA, FOR THE COMMERCIAL YEAR ENDING AUGUST 31, 1889.

[By J. P. Merrihew, superintendent Savannah Cotton Exchange.]

Receipts from all sources.

	Quantity.	Weight.	Value.
	Bales.	*Pounds.*	
Upland	798,628	389,554,765	$37,828,926
Sea Island	29,991	11,692,401	2,658,115
Total	828,619	401,247,166	$40,478,041

Exports from Savannah.

	Upland.	Sea Island.
	Bales.	*Bales.*
Coastwise	471,211	25,740
Great Britain	79,218	3,261
France	11,397	145
Other continental ports	229,728	130
Total	797,146	29,276

Summary.

	Quantity.	Weight.	Value.
	Bales.	*Pounds.*	
Upland	797,146	388,831,875	$ 7,808,533
Sea Island	29,382	11,453,985	2,605,008
Total	826,528	400,285,560	$40,413,541

Foreign exports:		
Upland	bales	325,935
Sea Island	do	3,642
Coastwise exports:		
Upland	do	471,211
Sea Island	do	25,740
Value per bale:		
Upland		$47.43
Sea Island		88.63
Total value		$40,537.041

Arrivals and clearances of vessels and commerce at Savannah, Georgia, from January 1, 1873, to December 31, 1889.

ARRIVED.

Years.	Coastwise.			Foreign ports.						Total.			Greatest draught.
				American vessels.			Foreign vessels.						
	No.	Tons.	Crew.	No.	Tons.	Crew.	No.	Tons.	Crew.	No.	Tons.	Crew.	
													Feet.
1873	463	381, 595	11, 934	34	16, 140	383	213	119, 316	2, 999	710	517, 051	15, 316	17. 50
1874	418	354, 700	10, 048	66	41, 030	847	284	182, 517	4, 232	768	578, 247	15, 127	17. 50
1875	370	310, 877	10, 102	67	39, 298	781	222	145, 748	3, 290	659	495, 923	14, 173	17. 50
1876	355	320, 015	10, 348	58	40, 832	987	260	169, 649	3, 865	673	530, 496	15, 200	17. 75
1877	333	379, 826	10, 867	54	40, 948	951	287	168, 247	3, 950	674	589, 021	15, 768	18. 25
1878	322	385, 532	10, 688	61	45, 208	1, 576	326	235, 787	5, 814	709	666, 527	18, 078	18. 50
1879	319	414, 794	8, 235	30	21, 994	439	279	198, 040	3, 960	628	634, 828	12, 634	17. 75
1880	338	446. 881	9, 996	14	7, 724	170	244	172, 224	3, 533	596	626, 829	13, 699	18. 33
1881	383	508, 422	11, 069	21	10, 729	237	254	151, 463	3, 474	658	670, 614	14, 780	19. 00
1882	391	544, 488	12, 605	11	4, 865	106	204	115, 061	2, 718	606	666, 374	16, 429	19. 00
1883	380	468, 226	10, 659	10	4, 115	90	160	87, 020	1, 965	550	559, 366	12, 714	18. 25
1884	388	482, 917	13, 735	14	5, 632	116	287	174, 676	3, 984	689	663, 225	17, 835	19. 00
1885	395	493, 610	14, 622	12	5, 058	125	251	163, 321	3, 416	658	668, 989	18, 163	20. 75
1886	393	503, 073	14, 534	10	5, 952	185	268	177, 229	3, 719	671	686, 254	18, 438	20. 00
1887	430	543, 235	15, 127	8	2, 725	60	231	130, 136	2, 800	669	676, 096	17, 987	20. 40
1888	411	539, 576	14, 907	8	3, 560	111	229	146, 075	3, 288	648	689, 211	18, 306	20. 67
1889	409	561, 463	15, 547	12	6, 563	154	309	215, 865	4, 530	730	783, 891	20, 231	20. 70

CLEARED.

1873	466	398, 050	13, 749	65	30, 102	689	224	129, 164	3, 194	755	557, 316	17, 632	17. 50
1874	480	407, 295	12, 748	71	40, 397	822	229	145, 038	3, 437	780	592, 730	17, 007	17. 50
1875	319	234, 831	9, 376	72	39, 311	804	195	128, 086	2, 924	586	452, 228	13, 104	17. 50
1876	410	361, 999	11, 222	80	49, 483	1, 163	185	119, 699	2, 827	675	531, 781	15, 212	17. 75
1877	400	439, 370	12, 081	65	44, 829	1, 066	161	103, 342	2, 489	626	587, 541	15, 736	18. 25
1878	378	418, 958	10, 475	64	40, 128	1, 255	260	183, 757	5, 375	702	642, 843	17, 105	18. 50
1879	365	442, 734	8, 834	36	24, 891	497	223	156, 470	3, 129	624	624, 095	12, 460	17. 75
1880	310	434, 864	10, 108	26	12, 536	271	242	168, 255	3, 446	578	615, 655	13, 825	18. 33
1881	369	508, 422	11, 458	22	13, 052	253	261	180, 579	3, 745	652	702, 053	15, 456	19. 00
1882	350	506, 213	11, 917	23	9, 155	205	209	135, 375	3, 023	582	650, 743	15, 145	19. 00
1883	355	415, 720	9, 780	10	4, 115	90	165	87, 400	2, 015	530	507, 235	11, 885	18. 25
1884	360	452, 802	13, 363	15	5, 634	131	288	194, 075	4, 315	663	652, 511	17, 809	19. 00
1885	414	502, 773	14, 672	20	8, 722	148	228	154, 858	3, 344	662	666, 353	18, 164	20. 17
1886	378	473, 134	13, 912	3	939	24	262	194, 793	3, 970	643	668, 867	17, 906	20. 00
1887	380	480, 030	14, 167	4	678	29	269	202, 656	4, 186	653	683, 364	18, 382	20. 00
1888	382	507, 075	14, 231	8	2, 583	63	233	167, 836	3, 557	623	677, 494	17, 851	.....
1889	395	540, 293	15, 505	7	1, 323	51	307	226, 181	4, 601	711	767, 747	20, 157	.....

COMMERCE.

Years.	Value of exports.*	Value of imports.*	Duties collected.	Years.	Value of exports.	Value of imports.	Duties collected.
1873	$29, 850, 275. 00	$890, 644. 00	$160, 011. 77	1881	$47, 488, 117. 00	$952, 512. 00	$356, 550. 22
1874	50, 500, 945. 94	788, 220. 00	110, 492. 74	1882	48, 349, 033. 00	657, 255. 00	61, 148. 70
1875	46, 004, 295. 60	511, 818. 00	61, 625. 44	1883	50, 890, 937. 00	567, 182. 00	65, 245. 34
1876	41, 236, 581. 00	511, 528. 00	58, 163. 36	1884	50, 934, 184. 00	696, 434. 00	49, 147. 28
1877	33, 569, 981. 00	564, 937. 00	34, 959. 93	1885	42, 253, 397. 00	513, 286. 00	45, 161. 40
1878	41, 793, 477. 71	505, 596. 00	23, 364. 35	1886	64, 724, 275. 44	655, 433. 00	35, 455. 53
1879	44, 980, 070. 89	378, 782. 00	27, 778. 73	1887	68, 301, 909. 00	181, 111. 00	48, 837. 12
1880	49, 297, 981. 25	660, 974. 00	78, 458. 41	1888*	17, 849, 916. 00	353, 611. 00	98, 213. 75
				1889†	.....	483, 396. 00	58, 815. 54

* Value of exports includes foreign and coastwise. Imports only foreign.
† Value of foreign exports only.

T. F. JOHNSON,
Collector.

REVISED PROJECT OF IMPROVEMENT FOR SAVANNAH HARBOR AND RIVER, WITH A VIEW TO OBTAINING A CHANNEL DEPTH OF TWENTY-SIX FEET.

UNITED STATES ENGINEER OFFICE,
Baltimore, Md., July 16, 1890.

GENERAL: I have the honor to send forward the report of Lieutenant Carter, dated June 30, 1890, with accompanying papers and maps, all relating to a revised project of improvement for the Savannah River near and below Savannah, Ga., with a view of obtaining a depth of 26 feet of mean low water from the city to the ocean.

This project and preceding survey are understood to be the result of the instructions of the Chief of Engineers, dated January 11, 1889. The work and the discussion of it are believed to be the best yet done for this river.

The project is approved, subject to such minor modifications as the progress of the work will surely suggest.

The estimate is also approved. If the money for the execution of the project were supplied as fast as it could be economically expended, the cost could be much reduced.

Very respectfully, your obedient servant,

WM. P. CRAIGHILL,
Colonel, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

[First indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
July 21, 1890.

Respectfully submitted to the Secretary of War.

The plan of improvement under which operations have been carried on up to date provides for the establishment of a channel from Tybee Roads to the city of Savannah practicable at high tide for vessels drawing 22 feet of water, and the widening of the channel of the river opposite the city to 600 feet, of uniform depth with the balance of the channel.

To comply with the provisions of the river and harbor act of August 5, 1886, a survey was made, under the direction of Col. Q. A. Gillmore, Corps of Engineers, of the "Savannah River from cross-tides above Savannah to the bar, with a view to obtaining 28 feet of water in the channel," and an estimate for the improvement was submitted amounting to $6,660,000 (Annual Report Chief of Engineers, 1888, Part II, pages 1059–1073). As no action has been taken on this report, and a mean high-water depth of 22 feet being insufficient to accommodate the large and rapidly-growing commerce upon the Savannah River, and the project for securing a depth of 28 feet requiring so large an expenditure, I directed Lieutenant Carter to prepare and submit a project with an estimate of the cost of obtaining a channel of 26 feet at high water, and it is in compliance with these instructions that the within project is submitted. It is recommended that the future operations on this river be directed to securing a depth of 26 feet, as within proposed, and that the project be amended in that particular.

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

[Second indorsement.]

JULY 22, 1890.

The recommendations of the Chief of Engineers in his indorsement are approved.

L. A. GRANT,
Assistant Secretary of War.

PROJECT OF LIEUTENANT O. M. CARTER, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., June 30, 1890.

GENERAL: I have the honor to submit herewith a revised project of improvement for Savannah Harbor and River with a view to obtaining a channel depth of 26 feet at mean high water from the city to the sea. The basis of this report is formed by the project submitted by me under date of August 25, 1887, the revision having been made in the light of the information obtained by the survey executed under my direction in 1889 and 1890.

This survey was in charge of Mr. E. A. Gieseler, assistant engineer, and his reports and appendices, which are submitted herewith as a part of this report, give a full description of the methods employed and the results obtained.

Apart from the development of the present form of the river-bed from cross-tides to the sea, by means of careful and numerous soundings, the aims of the survey were in the main directed toward a systematic investigation of the tidal conditions and of the ebb and flood flow in the various channels, and it appears that this object has been attained.

The results of the gauging operations as far as the volumes in motion under mean conditions of tide and of fresh-water flow are concerned may be summed up as follows:

Nearly equal volumes of flood enter the two openings north and south of Oyster Bed, viz., respectively, about 1,100,000,000 and 1,000,000,000 cubic feet, about 300,000,000 cubic feet of the former passing off into Wright's River. Savannah River proper is entered by a flood volume of about 1,850,000,000 cubic feet, of which one-fourth passes into South Channel while three-fourths enter the mouth of North Channel at the lower end of Jones's Island. Immediately below St. Augustine Creek the flood volume of South Channel has diminished to about 180,000,000 cubic feet, but is increased immediately above the flood inflow of said creek to 414,000,000 cubic feet. The volume of North Channel at about the same distance from the mouth (center of Spirit Island) is 770,000,000 cubic feet, of which somewhat more than one-tenth moves through Duck Puddle. The head of Elba Island is reached with an entire flood volume in North and South channels of about 1,100,000,000 cubic feet, of which amount about 760,000,000 cubic feet enter Back River and about 210,000,000 cubic feet enter Front River.

After having turned about 65,000,000 cubic feet over Cross Tides Dam into Front River the Back River flood arrives at Reeves plantation with about 125,000,000 cubic feet. The Front River flood has decreased to 114,000,000 cubic feet immediately below King's Island, but is increased by the inflow through Cross Tides to a volume of 140,000,000 cubic feet immediately above the latter place.

The ebb flow of Savannah River is increased by the accumulation of

half a lunar day's fresh-water flow, amounting to about 700,000,000 cubic feet. In Front River immediately above Cross Tides the ebb volume amounts to 856,000,000 cubic feet, of which nearly 600,000,000 cubic feet remains in Front River, while about 300,000,000, cubic feet pass over the dam into Back River. The ebb volume of the latter which, 1½ + miles further up at Reeves plantation, is only 165,000,000 cubic feet is thus considerably increased, so that at the junction of Back River and Front River in the vicinity of Barnwell islands it amounts to about 1,000,000,000 cubic feet, most of which doubtless passes through the opening south of the upper Barnwell Island. Front River, in the same vicinity, discharges about 700,000,000 cubic feet through the mouth of Wrecks Channel.

About the same amounts are turned respectively into North and South channels, so that half way down Spirit Island we find a total volume of about 1,160,000,000 cubic feet for the two openings of the North Channel, and in the same vicinity, immediately above St. Augustine Creek, about 770,000,000, cubic feet in South Channel. The flow in the latter is then weakened to the amount of nearly 350,000,000 cubic feet, passing off through St. Augustine Creek and at its mouth near Lazaretto Creek; we therefore find a discharge of only about 870,000,000 cubic feet, while about 1,700,000,000 cubic feet are discharged through the mouth of North Channel at the lower end of Jones's Island, rendering in all an ebb volume at the two mouths of the river of about 2,570,000,000 cubic feet.

Finally, about 1,450,000,000 cubic feet pass south and about 935,000,000 cubic feet pass north of Oyster Bed, in which latter is included a volume of about 300,000,000 cubic feet coming from Wright's River.

Such are the general outlines of the movement of volumes in the lower Savannah River as deduced from the present survey. As compared with former gauging operations a fairly good coincidence of results is found in the upper portion, while in the lower portion the present volumes are very considerably smaller than the former ones, possibly an indication of a decrease of the tidal volume and therefore a warning to proceed with the utmost caution in the construction of all future improvement works.

The effect of Cross Tides Dam is strikingly illustrated by the above. Previous to its construction two-thirds of the entire volume of Savannah River passed through Cross Tides into Back River, and only one-third passed down Front River. Now the situation is precisely reversed.

The relative size of volumes passing north and south of Oyster Bed is somewhat of a surprise, the importance of the northern opening being demonstrated by the survey to be much greater than was supposed. We should then proceed cautiously in the construction of such works as may be intended to partially close this opening.

The results of the survey appear to indicate that a mean ebb velocity of about 2 feet per second is required to secure permanence of the channel. The general aim of the revised project will be to mold the riverbed from Cross Tides to the sea in such a way as to allow the free ascent of the flood-tide, and to secure throughout, as far as practicable, the above uniform mean velocity of ebb flow. For Front River this leads us to cross-sectional areas for mean ebb out-flow increasing from about 9,000 square feet at Cross Tides to about 12,600 square feet at the mouth of Wrecks Channel, while the widths (under the assumption of a uniform mean depth of 18 feet for mean service of ebb out-flow) should increase from 500 feet at Cross Tides to 600 feet at Kinzey's Point, and from 700 to 750 feet at the mouth of Wrecks Channel.

For North Channel the same assumptions in regard to mean ebb velocity and mean depth lead to a general increase in widths from 1,200 feet at the head of Elba Island to 1,870 feet at Long Island Crossing, which, especially below, is more than the present widths between wing-dams.

In view of the foregoing the following plan of improvement is submitted:

The enlargement of Drakie's Cut as indicated in the original project.

The entire or partial removal of King's Island with a view of turning additional volumes into Front River and thereby somewhat increasing the velocities.

The construction of a deflecting jetty from Argyle Island.

The partial removal of Marsh Island and closing of the channel north of it with a view of throwing the entire flow into the enlarged southern channel and thus doing away with the disadvantages incident upon two channels. Besides this the area of the abandoned channel will furnish a convenient dumping-ground.

A training-wall from the lower end of Marsh Island to Kinzey's Point and the widening of the unduly contracted region below Kinzey's Point.

A training-wall in the vicinity of Garden Bank in order to properly contract the river there.

Spur-jetties or bank protection in the lower portion of Wreck's Channel for the same purpose.

Besides the dredging required to open up the river as discussed above, a channel 26 feet deep at mean high water from the city water-works to the sea is provided for.

A deflecting jetty running out toward South Channel from Mackey's Point in order to divert a greater ebb volume into North Channel.

The removal of a portion of Dam 15.

The closing of Duck Puddle in order to render permanent the improvement of North Channel near the lower mouth of Duck Puddle. The construction of training-walls and shore protection in the concave bend near Spirit Island and between wing-dams in North Channel, with a view of obtaining a strong ebb flow of uniform mean velocity throughout.

Training walls and shore protection between the Lower Flats and Oyster Bed.

Dredging south of Oyster Bed with a view of obtaining cross-sectional areas of about 45,000 square feet for mean ebb outflow, in order to induce a stronger flow through the southern opening and thence over Tybee Knoll.

In pursuance of the same object it may become necessary to close the northern opening either by continuing the present jetty, No. 31, to the shore, or by building a training wall from Long Island Flats to Oyster Bed; further to construct a training-wall running easterly from the lower end of Cockspur Island and finally to extend and raise the Oyster Bed training-wall. For the successful accomplishment of this improvement great freedom of action should be allowed the local engineer, the necessity for the various works and their execution being accompanied and guided by continued careful investigations of the influence exercised by the completed portions.

ESTIMATES.

Above Cross Tides:		
Drakie's Cut—		
160,000 cubic yards dredging, at 15 cents per cubic yard	$24,000	
800 linear feet of training-wall, at $8 per foot	6,400	
		$30,400
Cross Tides to Fort Oglethorpe:		
12,800 linear feet of training-wall, at $8 per foot	102,400	
1,400 linear feet of shore protection, at $8 per foot	11,200	
Partial removal of King's Island—770,000 cubic yards dredging, at 15 cents per cubic yard	115,500	
Partial removal of Marsh Island—500,000 cubic yards dredging, at 15 cents per cubic yard	75,000	
City Water Works to Vale Royal Mills, to open up cross-sections to the required size and to obtain a channel 300 feet wide and 26 feet deep at mean high water—700,000 cubic yards dredging, at 15 cents per cubic yard	105,000	
Vale Royal Mills to Fort Oglethorpe, as above—2,000,000 cubic yards dredging, at 15 cents per cubic yard	300,000	
Possible land damages to Hutchinson's Island	45,000	
		754,100
Fort Oglethorpe to Oyster Bed:		
Mackey's Point training-wall—		
1,080 linear feet of log and brush-mattress jetty—30,000 square yards of log and brush-mattresses at 60 cents per square yard	18,000	
4,500 cubic yards of stone at $3.50 per cubic yard	15,750	
51,150 linear feet of training wall, at $10 per foot	511,500	
8,000 linear feet of shore protection, at $10 per foot	80,000	
3,000 linear feet of shore protection, at $15 per foot	45,000	
Extending dams Nos. 27 and 35 to shore—1,800 linear feet of pile dam, at $10 per foot	18,000	
Obstructions—To open cross-sections to the required size and to obtain a channel 400 feet wide and 26 feet deep at mean high water—250,000 cubic yards dredging, at 15 cents per cubic yard	37,500	
Upper flats, as above—330,000 cubic yards dredging, at 15 cents per cubic yard	49,500	
Lower flats, as above—385,000 cubic yards dredging, at 15 cents per cubic yard	57,750	
Long Island crossing to oyster bed, as above—900,000 cubic yards dredging, at 15 cents per cubic yard	135,000	968,000
Oyster Bed to Tybee Roads:		
Oyster bed training wall—raising it to 2½ feet above mean low water, and extending it to Tybee Roads; constructing south training-wall to a height of mean low water:		
200,000 square yards of log and brush-mattresses, at 60 cents per square yard	120,000	
210,000 cubic yards of stone, at $3.50 per cubic yard	735,000	
16,600 cubic yards of stone, at $5 per cubic yard	83,000	
Oyster bed shoal to open up cross-sectional areas to required size—2,205,000 cubic yards dredging, at 15 cents per cubic yard	330,750	
Tybee Knoll, as above, and to secure a channel 400 feet wide and 26 feet deep at mean high water, 751,000 cubic yards dredging, at 15 cents per cubic yard	112,650	
		1,381,400
		3,133,900
In case the total removal of King's Island is decided upon, the volumes to be dredged will be increased by 730,000 cubic yards, which, at 15 cents per cubic yard, equal		109,500
		3,243,400
Engineering and contingencies, 10 per cent		324,340
Total		3,537,720

The estimated cost of the above improvement is, in round numbers, $3,500,000. These estimates are made upon the supposition that funds sufficient for advantageous prosecution of the work will be regularly supplied.

Respectfully submitted.

O. M. CARTER,
First Lieutenant, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER FROM CROSS TIDES TO THE SEA.

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REPORT OF MR. E. A. GIESELER, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., January 31, 1890.

SIR: I have the honor to report as follows upon the hydrographical survey of the Savannah River from Cross Tides to the sea.

Your letter of instructions to Mr. W. R. Curtis, of October 4, 1888, calls for the following work:

1. A quadrilateral system of triangulation from Cross Tides to the sea, including careful measurements of bases.
2. Location of shore-line and other topography by stadia measurements.
3. Location of wharf-lines along the city front by transit and steel tape.
4. Extension of the present line of levels beyond Fort Pulaski to Tybee Island.
5. Determinations of azimuth by observation of Polaris.
6. Soundings from Cross Tides to Fort Oglethorpe, at Obstructions, at head of South Channel, and from the Upper Flats to Tybee Roads.
7. Tidal observations at Cross Tides, Read's Mill, Central Railroad Slip, Barge Office, Savannah, Florida and Western Railway Wharves, Fort Oglethorpe Obstructions, St. Augustine Creek, Spirit Island, Lower Elba Island, Venus Point, and Fort Pulaski.
8. Observations of direction of currents by floats or loaded rods.
9. Observation of velocity of currents, preferably by current meters, above Cross Tides, below Cross Tides (Front River), at Fig Island (both channels), at Spirit Island, South Channel, St. Augustine Creek, and at Long Island (both channels).
10. Borings on Tybee Knoll.
11. A detailed report giving all methods and results, charts of the river, tidal diagrams, velocity of curves, discharge cross-sections, slope profiles, etc.

At the time I was entrusted by you with the completion of the survey, the first four of the above items were practically completed, with this modification, however, that from the lower end of Fig Island to the lower end of Marsh Island, a transit line had been substituted in the place of the triangulation called for.

No determination of azimuth by sidereal observations had been made, the required information being obtained from Coast Survey data.

The soundings in the lower portion had been about completed; above Fort Oglethorpe, however, there remained considerable space not covered and the soundings there did not check quite satisfactorily.

No tidal observations had been made beyond those required for the reduction of soundings. For the establishment of the mean low water plane and other mean tidal data, throughout the Lower Savannah, a series of not very reliable observations, made in 1887, had been used.

No observation of direction of current had been made.

A limited number of current-velocity observations were made with Buff & Berger meters, the latter being alternately lowered and raised with as uniform a motion as possible in order to obtain the mean velocity of the vertical.

No borings had been taken.

Of the office work the computation of the triangulation was practically done, though neither well arranged nor thoroughly checked; the river charts, based on a preliminary plat of the triangulation, were in an advanced state of completion.

Summing up, then, there chiefly remained to be done observations of currents and tides at the places mentioned, soundings above Fort Oglethorpe. and, possibly, in Back River, and in South Channel as far down as St. Augustine Creek, borings, and finally the various items of office work.

According to verbal instructions received from you, the current observations at Fig and at Long Island were for the present left out, the conclusion having been arrived at that the results of the discharge computations could be sufficiently well obtained and checked without their aid. The observations of direction of current were likewise left out for the present.

With the exception of these, some soundings, and that part of the office work which is still under way at the time of writing, the work directed by your letter of instructions has been completed, and I now proceed to report upon the same and more particularly on that portion of it which was intrusted to me, viz, the gauging of the river, the borings, and the office work.

Excepting the borings, the field work was executed between the 4th of April and the 25th of May, 1889, and its results, aside from the river charts, are represented on the following diagrams, which accompany this report:

Sheet.	Subject.
1	General sketch of survey.
2	Semimenstrual inequality of time.
3	Semimenstrual inequality of height.
4	The lines of high and low water in Front River and North Channel.
5	The lines of high and low water in Back River and South Channel.
6	Mean tidal curves, Front River and North Channel.
7	Mean tidal curves, Back River and South Channel.
8	Mean tidal curves, Cross Tides.
9	Mean ebb slopes, Front River and North Channel.
10	Mean flood slopes, Front River and North Channel.
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12	Mean flood slopes, Back River and South Channel.
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15	Gauged cross-sections.
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18	Example showing method of determining mean elevation of surface above mean low water during ebb and flood flow.
19	Mean ebb and flood velocities at different depths; lines A and B.
20	Mean ebb and flood velocities at different depths; lines C, E, and G.
21	Mean ebb and flood velocities at different depths; lines D and F.
22	Maximum ebb and flood velocities at different depths; lines A and B.
23	Maximum ebb and flood velocities at different depths; lines C, E, and G.
24	Maximum ebb and flood velocities at different depths; lines D and F.

1. Tidal Observations.

Tide gauges were established at the following fourteen points on Front and Back River, South and North Channel:

1. Cross Tides, upper (Front River).
2. Cross Tides, lower (Back River).
3. Recess.
4. Read's Mill.
5. Central Railroad Pier.
6. Barge Office.
7. Savannah, Florida and Western Railroad Pier.
8. Fort Oglethorpe.
9. St. Augustine Creek.
10. Obstructions.
11. Spirit Island.
12. Lower Elba Island.
13. Venus Point.
14. Fort Pulaski.

The location of each gauge is shown on the general sketch of the survey, Sheet No. 1.

Cross Tides, upper, Barge Office, Fort Oglethorpe, and Fort Pulaski were made standard points of observation, and for four and one-half months, day and night, observations of time and height of high and low water, were continued at these points. At Cross Tides, upper, and Barge Office ordinary tide-staffs were established, which were read by reliable men stationed there. At Fort Oglethorpe and Fort Pulaski self-registering tide-gauges were put up, one of the Coast Survey pattern at the former place and one of A. Stierle's pattern at the latter place.

With the exception of Recess, which was observed only two days, continuous read-

ings every five minutes, from sunrise to sunset, were taken at all the other stations during the first three weeks of the survey—that is, from about the beginning of April to about April 23; thence to May 9, high and low waters only were observed, but those occurring during night time as well as those occuring during daytime. This arrangement was modified while current measurements were being made in the vicinity of any one tide-gauge, when not only continuous readings were taken on the same every five minutes during daytime, but also the high and low waters occurring during the night were observed.

The time employed for all observations, tidal as well as current measurements, was Savannah local time. Each tidal station was visited every few days in order to furnish it with correct time and to enter in the book the error of time found when the visit was made.

On May 9 observations on all tide gauges were discontinued, excepting on the four standards and on those in the vicinity of which current measurements were being made. Towards the middle of August about two hundred and fifty high and as many low water observations of time and height had been obtained on each of the standard gauges, and observations were now stopped on the two upper ones, it being concluded that the results obtained so far would form a satisfactory basis of the tidal part of the survey. The self-registering gauges at Fort Oglethorpe and at Fort Pulaski were continued in order to get a more complete record at these points for future investigations.

The first step towards the methodical treatment of the above-mentioned observations consisted in making the so-called "first reductions" according to the following schedule for high water, a similar one being employed for low water:

Observations of high water at cross-tides, 1889, *first reduction*.

Observed date and time of high water. April.	Date and time of generating lunar transit.	Lunitidal interval.	Lunar.		Observed reading of gauge.
			Declination.	Parallax.	
			Degrees.	*Minutes.*	*Feet.*
18.....11h 22	18..... 2h 42	8h 40	—19	59	7.52
18.....23 30	18.....15 12	8 18	—20	59	6.70
Etc.	Etc.	Etc.	Etc.	Etc.	Etc.

From the first reductions an abstract was made of the lunitidal intervals and the readings of high and low water, grouping them in each case in twelve columns according to the hour of lunar transit, the low water always being referred to that transit which generated the preceding high water. The more accurate way of grouping into twenty-four-hour columns could not be attempted on account of the limited number of observations.

The heights of high water and the lunitidal intervals of low water were each arranged in two series, one containing those incident on—

1. Upper transits during southern declination.
2. Lower transits during northern declination; and the other containing those incident on—
1. Upper transits during northern declination.
2. Lower transits during southern declination.

The first of these two series contains the lower high-waters and the shorter low-water lunitidal intervals, while the second contains the higher high-waters and the longer low-water lunitidal intervals. From the difference between the means of corresponding hour columns of the two series, the influence of lunar declination on the height of high water and the time of low water, in other words the diurnal inequality of these two items, was found. A difference of 10° in lunar declination proved to cause a difference of about 0.26 foot in the height of high water, and about six and a half minutes in the time of low water, the difference being subtractive when the tide belongs to the first lunar series and additive when it belongs to the second. At those times, therefore, when the moon's declination reaches its maximum the diurnal inequality caused by it on the lower Savannah River will amount to about 1½ feet in the height of high water and about forty minutes in the time of low water.

The diurnal inequality of the height of low water and the time of high water being caused by solar influence is much less marked than the foregoing and therefore more overshadowed by other influences, such as wind and fresh-water flow. The series of observations available was not long enough to determine it.

From the means found for each of the 12-hour columns, into which the observations of time and height of high and low water had been grouped, the curves of the

semimenstrual inequality of tides were constructed, those for the time being represented on sheet No. 2 and those for the height on Sheet No. 3.

It will be noticed that the shape of the time-curves, both for high and for low water, does not materially change as we advance up the river; in other words the velocity of propagation is not affected to any great extent by the hour of the moon's transit. As far as this latter only is concerned and apart from other influences, it will never vary much from the mean.

With the curves of semimenstrual inequality of the height of high and low water, it is quite different; they are all of them more and more flattened the higher up the river we go and the more predominant therefore the influence of the fresh-water flow becomes. While at Fort Pulaski the difference between mean neap and mean spring-tide is about 2 feet, it is only 1½ feet at Fort Oglethorpe, 1.3 feet at barge office, and 0.80 foot at Cross Tides upper.

Time and height of mean high and mean low water at the four standard stations were found by taking the mean of the twelve means obtained from the hour columns after such means had been found to correspond to mean conditions of lunar parallax and declination.

The mean tidal establishments at the other stations were found by referring each of them to the two standards, between which it was located. For instance, from about forty observations at Central Railroad pier it was found that the average high-water reading on the staff there was 0.78 less than at Cross Tides and 0.31 more than at barge office, while low water read 1.53 less than at Cross Tides and 0.97 more than at barge office, all of which figures will be understood to refer to the actual positions in height occupied by each staff, and not reduced to a common plane of reference. Again high water was found to occur at Central Railroad pier fourteen minutes earlier than at Cross Tides and eleven minutes later than at barge office, while low water occurred thirty-one and one-half minutes earlier than at Cross Tides and twenty-two and one-half minutes later than at barge office.

Employing now the known tidal data of Cross Tides and barge office, the operations would stand this way:

DETERMINATION OF TIDAL ESTABLISHMENT AT CENTRAL RAILROAD.

1. *High water.*

Reading of mean high water at Cross Tides	6.27
	−0.78
	5.49
Reading of mean high water at barge office	5.30
	+0.31
	5.61
Consequently mean high water at Central Railroad	5.55
Corrected establishment at Cross Tides	h m 8 37
	— 14
	h m 8 23
Corrected establishment at barge office	h m 8 14½
	+ 11
	h m 8 25½

Consequently corrected establishment at Central Railroad $8^h\ 24^m$.

2. *Low water.*

Reading of mean low water at Cross Tides	1.81
	−1.53
	0.28
Reading of mean low water at barge office	−0.77
	+0.97
	0.20
Consequently mean low water at Central Railroad	0.24

	h	m
Mean lunitidal interval of low water at Cross Tides	16	29
	—	31½
	15	57½
Mean lunitidal interval of low water at barge office	15	36
	+	22½
	15	58½

Consequently mean lunitidal interval of low water at Central Railroad, $15^h\ 58^m$.

In this way each of the intermediate results was deduced as the mean of two independent operations and reliable tidal data were thus obtained for all stations. The figures for height of high and low water so found were finally reduced to the plane of mean low water at Fort Pulaski, on the basis of the line of levels previously run from Cross Tides to Tybee Island. The tidal data for the latter were found in the above-described manner by comparing one month's record of the Coast Survey tide gauge recently established there with the record of the same period at Fort Pulaski.

The final results thus found are given in the following two tables, the first one containing the line of tide gauges along Front River and North Channel and the second one containing those along Bank River and South Channel, Fort Pulaski and Fort Oglethorpe being common to both.

It should be mentioned here that Venus Point and Spirit Island have not been included in the above-mentioned line of levels; the height of the tide gauges there above the plane of reference had therefore to be established by interpolation.

TABLE NO. 1.—*Tidal data on the Lower Savannah River.*

FRONT RIVER AND NORTH CHANNEL.

No.	Name of station.	Corrected establishment.	Mean lunitidal interval of low water.	Mean duration of—		Height above Fort Pulaski, mean low water of.		Mean rise and fall.
				Fall.	Rise.	High water.	Low water.	
		h. m.	*h. m.*	*h. m.*	*h. m.*			
1	Tybee Island	7 15½	13 26	6 10½	6 14½	6.90	0.02	6.88
2	Fort Pulaski	7 15½	13 54	6 38½	5 46½	6.97	0.00	6.97
3	Venus Point	7 31	14 22	6 51	5 34	7.15	0.22	6.93
4	Lower Elba Island	7 40	14 39	6 59	5 26	7.23	0.34	6.89
5	Spirit Island	7 46	14 56	7 10	5 15	7.29	0.55	6.74
6	Obstructions	7 54	15 03	7 09	5 16	7.38	0.67	6.71
7	Fort Oglethorpe	8 04	15 16	7 12	5 13	7.33	0.72	6.61
8	Savannah, Florida and Western Railroad pier	8 07	15 24½	7 17½	5 07½	7.48	1.11	6.37
9	Barge office	8 14½	15 36	7 21½	5 03½	7.41	1.34	6.07
10	Central Railroad pier	8 24	15 58	7 34	4 51	7.51	2.20	5.31
11	Read's Mill	8 30	16 13½	7 43½	4 41½	7.46	2.62	4.84
12	Cross Tides, upper	8 37	16 29	7 52	4 33	7.48	3.02	4.46

BACK RIVER AND SOUTH CHANNEL.

1	Fort Pulaski	7 15½	13 54	6 38½	5 46½	6.97	0.00	6.97
2	St. Augustine Creek	7 50	14 49½	6 59½	5 25½	7.29	0.47	6.82
3	Fort Oglethorpe	8 04	15 16	7 12	5 13	7.33	0.72	6.61
4	Cross Tides, lower	8 31	16 04	7 33	4 52	7.54	1.06	6.48
5	Recess	8 32	16 20	7 48	4 37	7.41	1.43	5.98

The highest high waters and lowest low waters observed at the standard tide-gauges were as follows:

Highest high waters and lowest low waters observed on Savannah River from April to August, 1889.

	High water.	Low water.
Fort Pulaski	9.30	—0.97
Fort Oglethorpe	9.21	—0.48
Barge office	9.24	0.41
Cross Tides, upper	9.11	1.46

In this table as everywhere in this report and appended diagrams, the heights are referred to mean low water at Fort Pulaski.

In judging of the closeness with which these figures approach the actual extremes of high and low water ever occurring on the Lower Savannah River, it should be remembered that during the entire duration of the survey no heavier freshet occurred than one rising to 20 feet at the Augusta gauge, at which point the water has been known to rise to nearly twice that height. A freshet like this would doubtless cause considerable higher high waters at cross tides than noted above.

Again, during the continuance of tidal observations no protracted and heavy easterly gales have occurred, the former of which might have caused higher high waters, while the latter might have caused lower low waters than here noted. As a matter of fact the high water at Fort Pulaski in August, 1881, during a tremendous easterly gale rose to more than 16 feet above mean low water, and I am reliably informed that on various occasions the low water fell to more than 3½ feet below mean low water.

From the distances between the tide-gauges and the times of high and low water the duration and the rate of propagation have been found as follows:

TABLE NO. 2.—*Propagation of tidal wave on Savannah River.*

FRONT RIVER AND NORTH CHANNEL.

No.	Name of station.	Distance.	Time of propagation.		Rate of propagation in feet per minute.	
			High water.	Low water.	High water.	Low water.
		Feet.	*h. m.*	*h. m.*		
1	Tybee Island	.....	0 00	0 00	.....	.....
2	Fort Pulaski	18,000	0 00	0 28	.....	464
3	Venus Point	19,800	0 15½	0 56	1,277	707
4	Lower Elba Island	10,130	0 24½	1 13	1,126	596
5	Spirit Island	11,500	0 30½	1 30	1,917	676
6	Obstructions	7,330	0 38½	1 37	916	1,047
7	Fort Oglethorpe	7,750	0 48½	1 50	775	596
8	Savannah, Florida and Western Railroad pier	7,930	0 51½	1 58½	2,643	933
9	Barge office	6,900	0 59	2 10	920	600
10	Central Railroad pier	11,220	1 08½	2 32	1,181	510
11	Read's Mill	5,750	1 14½	2 47½	958	371
12	Cross Tides, upper	8,000	1 21½	3 03	1,143	516

BACK RIVER AND SOUTH CHANNEL.

1	Fort Pulaski	.....	0 00	0 00	.....	.....
2	St. Augustine Creek	44,660	0 34½	0 55½	1,295	805
3	Fort Oglethorpe	14,900	0 48½	1 22	1,064	562
4	Cross Tides, lower	36,780	1 15½	2 10	1,362	766

In Table No. 2, we find great irregularities, especially in the rate of propagation of high water in Front River and North Channel irregularities which probably do not exist in reality, but are due to the great difficulty of determining the accurate rate

of propagation for short distances, a difficulty which will be understood when it is considered that comparatively insignificant changes in the time of Table No. 2 may cause radical ones in the rate of propagation. By assuming, for instance, an error of time of one minute for Fort Oglethorpe and one of two minutes for Savannah, Florida and Western Railroad pier, the most glaring case of irregularity is at once brought down to modest proportions, the velocity of the high water between these two points being reduced from 2,642 feet to 1,321 feet per minute. Inasmuch as the mean lunitidal intervals found can not be claimed to be any closer to truth than a few minutes, it will be seen that no great reliance can be placed on the rates of propagation as given above.

If the intermediate tide-gauges are left out and only the standard ones are considered, thus introducing much greater distances and larger intervals of time, then the results are much more uniform, as the following table will serve to show:

TABLE NO. 3.—*Propagation of tidal wave on Savannah River.*

FRONT RIVER AND NORTH CHANNEL.

No.	Name of station.	Distance.	Time of propagation.		Rate of propagation in feet per minute.	
			High water.	Low water.	High water.	Low water.
		Feet.	*h. m.*	*h. m.*		
1	Tybee Island	.....	0 00	0 00	.....	.....
2	Fort Pulaski	13,000	0 00	0 28	.....	464
3	Fort Oglethorpe	56,510	0 48½	1 50	1,165	689
4	Barge office	14,830	0 59	2 10	1,422	742
5	Cross Tides, upper	24,970	1 21½	3 03	1,110	471

BACK RIVER AND SOUTH CHANNEL.

1	Fort Pulaski	.....	0 00	0 00	.....	.....
2	Fort Oglethorpe	59,560	0 48½	1 22	1,228	726
3	Cross Tides, lower	36,780	1 15½	2 10	1,362	766

Strange to say, it would seem that the contraction of Front River above Fort Oglethorpe is reflected in a more rapid movement of the tidal wave immediately above the point. But even table No. 3, with its greater distances and intervals, does not establish anything with certainty beyond this, that the propagation of tide in North Channel and Front River takes place with an average velocity of 1,182 feet per minute for the high water and 621 feet per minute for the low water, and, further, that in South Channel and Back River the same movements take place, with average velocities of, respectively, 1,276 feet and 741 feet per minute. Again, comparisons have shown that westerly winds accelerate and easterly winds retard the propagation of high water. Finally, the further progress of the tide to Purysburg, a distance of 19 miles above Cross Tides, appears to be made at the average rate of about 480 feet per minute for both high water and low water, the mean lunitidal intervals having been found from about thirty observations, as follows:

Purysburg:

Corrected establishment ..... $12^h\ 10^m$

Mean lunitidal interval for low water ..... $20^h\ 00^m$

from which it would appear that the mean duration of rise and that of fall is almost the same at Purysburg as at Cross Tides. The mean range of tide at the former place has diminished to about 1 foot and is felt only a few miles farther, say altogether to a distance of about 42 miles from Fort Pulaski.

The subject of the velocity of propagation of the tidal wave is thus found comparatively barren of results, and the main reason for the writer's entering on it to the extent he has done was to show the treacherous nature of this ground, and consequently the inadvisability to erect on it any complicated structure of reasoning and conclusions. A graphical representation of the propagation of high and low water, together with other tidal events, is rendered on sheets Nos. 13 and 14.

The mean rise and fall of tides in both Front River and Back River gradually diminishes from the mouth upwards, the decrease being brought about mainly through the rising of the low-water plane. The high and low water lines of Front River and

North Channel and those of Back River and south channel are shown on sheets No. 4 and No. 5, respectively, and from a glance at them we perceive the great difference existing in the upper part between the low-water planes of Front and Back rivers. At Cross Tides the mean low-water plane of the former is about 2 feet higher than that of the latter and the mean rise and fall as much smaller, a condition that was undoubtedly brought about by the construction of the Cross Tides dam, which now in a measure blocks the outlet, through which formerly the greater volume of the ebb was discharged. In discussing the results of the current observations this subject will be treated more in detail.

On sheets 4 and 5 are also platted the lines of high and low water during actually observed spring tides, and it is seen from them that relatively the heights do not undergo any great change as compared with mean tides. It is quite different, however, with the same lines during a freshet, as shown on sheet No. 4. While the high waters do not experience any material change of relative height, the low waters in the upper river are raised very considerably. Any doubt existing as to the presence of a freshet in the river at any particular time can easily be solved by platting the low waters observed during such time. If the line connecting them in the upper part of the river shows a materially steeper grade than the line connecting the mean low waters, then we have the characteristic indication of a freshet.

On sheets No. 6, No. 7, and No. 8 are platted the mean tidal curves as deduced for the location of the various tide-gauges. They are arranged according to time and height so that their intersections with any one of the vertical time-lines show the synchronous state of the river's surface existing at that particular time, as referred to the Fort Pulaski mean low-water plane. The arrangement in height is based on the excellent line of levels that had previously been run by Mr. A. S. Cooper from Cross Tides to Tybee Island. It seems proper here to state that the extensions of this line of levels to Recess and to St. Augustine Creek were run in haste, and the degree of accuracy is not therefore claimed for them, which is claimed for the main line and made so conspicuously manifest by its application to the tidal results.

In order to construct the mean tidal curves a great number of actually observed tides were platted and from a careful study their peculiarities of form were evolved; those of them that conformed most to mean duration and mean height were then reduced to such mean conditions by graphical process. The result thus obtained does not therefore represent actually observed phenomena, but ideal ones, deduced from them for the purpose of forming a uniform basis to which the results of current observations made under different tidal conditions could be reduced.

From the diagrams of tidal curves the slope diagrams were prepared, sheet No. 9 and 10 giving the ebb and flood slopes for Front River and North Channel and sheet No. 11 and 12 giving the same for Back River and South Channel. From these diagrams we perceive that the course of events from one lunar transit to the next, as far as the surface slope is concerned, is about as follows:

At moon's transit. Maximum ebb slope (0.000032) below Fort Oglethorpe, remaining for about one-half hour longer. Above Fort Oglethorpe the ebb slope is still increasing.

I^{H}.—Maximum ebb slope now probably near Fort Oglethorpe, below which place the ebb slope is declining and above which it is still increasing.

II^{H}.—Maximum ebb slope (0.000053) near Barge Office since about one-half hour, remaining about one-quarter hour longer.

A small ebb slope still remains below Fort Oglethorpe, but ceases at the lower end of Elba Island, between which and Fort Pulaski the surface is level.

III^{H}.—Maximum ebb slope (0.000070) between Central Railroad and Cross Tides, below the former of which the ebb slope is now declining rapidly. The slope below Fort Oglethorpe has turned flood.

IV^{H}.—Maximum flood slope (0.000016) below Fort Oglethorpe, remaining for one and one-half hours. The flood slope has advanced as far up as Barge Office, above which point the ebb slope is declining rapidly.

V^{H}.—No slope from Barge Office to Cross Tides.

VI^{H}.—Maximum flood slope (0.000010) between Fort Oglethorpe and Central Railroad.

VII^{H}.—Maximum flood slope (0.000010) between Cross Tides and Central Railroad about one-half hour ago. No slope between Fort Pulaski and lower end of Elba Island.

VIII^{H}.—Practically no slope above Fort Oglethorpe. The slope below has turned ebb.

IX^{H}.—The entire slope has turned ebb and is increasing.

X^{H}, XI^{H}, XII^{H} } The same.

In the Back River from Recess to Fort Oglethorpe the course of events is as follows:

At moon's transit: Ebb slope throughout, increasing everywhere.

I^{H}.—The ebb slope has just reached its maximum (0.000035), which remains stationary for about forty-five minutes.

II^{H}.—The ebb slope has commenced to decline slowly,

III^{H}.—The ebb slope is now declining rapidly.

IV^{H}.—The slope has turned flood about one-half hour ago, and is still increasing.

V^{H}.—The flood slope reached its maximum (0.000025) about one-half hour ago and now declines slowly.

VI^{H}.—The flood slope continues to decline slowly.

VII^{H}.—The same.

VIII^{H}.—The flood slope continues to decline slowly and vanishes in about ten minutes.

IX^{H}.—The ebb slope increases.

X^{H}. }
XI^{H}. } The same.
XII^{H}. }

In comparing this chronology of the changes of slope with the chronology of other tidal phenomena as represented on sheet No. 13 and 14, it will be noticed that the change of current in all cases takes place somewhat later than the reversion of slope. This is in accordance with observations at other points, which go to show "that the great mass of water continues its acquired motion after the slope has reversed. (Prof. Henry Mitchell, page 310, Coast Survey report 1887.)

The occurrence of maximum current does not as well coincide with the occurrence of maximum slope, due doubtless to the great difficulty of determining the exact time of both, but especially of the latter.

In accordance with what would naturally be expected it will be noticed further that the maximum ebb slope increases as it advances up the river, while the maximum flood slope declines.

As an easily-remembered rule we may finally gather the following from sheet No. 13:

"At the lower end of the Savannah pier line (S. F. & W. R. R. wharves) maximum ebb current runs at the time of moon's transit, while maximum flood current runs at a time half way between two transits succeeding each other."

Before leaving the subject of tides I would once more respectfully call attention to the fact that the basis of tidal computations is formed by only about four and one-half months' observations on the standard gauges. Observations on two of them have been continued and by the time this report is handed in nearly a full year's record will be available. I would urgently recommend the working up of these data, which would enable us to analyze the various heavenly influences sufficiently well to make good predictions of time and of height on Savannah River. I would further recommend tidal observations at two points, say about 7 and 14 miles above Cross Tides which in connection with the observations already made at Purysburg, would give valuable further information about the extent and the volume of the tidal prism.

2. CURRENT OBSERVATIONS GENERALLY.

Turning now to the discussion of the most important part of the survey, viz, the current observations, it seems pertinent first of all to mention the general conditions under which they were made and the method adopted to reduce their results to uniform mean conditions.

The two factors determining the flow are the volume of the tidal prism and the amount of fresh-water flow, both of which are variable and will therefore in their combination produce an almost endless variety of results. Any measurement of ebb outflow or of flood inflow made can, therefore, be of value only if the conditions are stated under which they were executed, and, in order to utilize a number of such results obtained at various times, they should be reduced to the uniform basis of mean volume of tidal prism and mean fresh-water flow. The first correction has been made by assuming the rise and fall of tide to be directly proportional to the volume of the tidal prism, and consequently to the entire outflow or inflow through a given cross-section. The second correction has been made by reference to the observations at the Augusta gauge, a reading of 10 feet on the same having been assumed as representing a mean state of the upper river, and consequently of fresh-water flow. The relation between the two latter items was obtained from a table given by Mr. George

W. Brown, assistant engineer, in his report to you of February 11, 1889, as follows:

Reading of gauge at Augusta.	Corresponding discharge in cubic feet per second.
5.0	2,500
8.0	6,100
10.6 (mean)	10,400
15.0	22,700

It is generally accepted that the conditions existing in the river at Augusta, make themselves felt at Savannah about eight days later, and with this assumption the above figures were applied to the results of current observations, in this way that any excess of fresh-water flow above the mean was substracted from the ebb outflow and added to the flood inflow, while any deficiency was added to the former and subtracted from the latter. The weak points of the method consists in the difficulty of determining accurately the time when a given condition of river at Augusta makes itself felt at Savannah, and furthermore in the fact that only the variations of fresh-water flow in the upper river were considered, while those below Augusta were ignored. The first deficiency was prevented from becoming a serious source of error in our particular case through the fact that the changes in the river at Augusta during the important parts of the survey were slight and gradual, the gauge-readings varying from the 8-foot mark to the 10-foot mark only. The second deficiency, however, remains and very probably has become a source of error, although hardly a serious one, because the importance of the river basin below Augusta is much the inferior one, it not only being less than one-half the area of the one above (3,200 square miles against 7,300), but also in the main consisting of flat ground, that will render a larger percentage of evaporation and absorption and consequently a smaller percentage of flow. If it is considered in connection with this, that the observations at Augusta show a state of the river throughout, departing only inconsiderably from the one assumed as normal, and further that the records of precipitation during the time of the survey are about the same for the upper and the lower basin, then the inference is justified that the lower portion of the basin did not experience any variations of flow materially affecting the results arrived at.

The fact of the cross-sections, with one single exception of minor importance, all having been gauged during a period of small and gradual changes of fresh-water flow never departing much from the mean of the same, therefore has an exceedingly important and favorable bearing upon the reliability of the final results and must be looked upon as a very fortunate circumstance. Aside from what was said above, the comparative smallness of the corrections for fresh-water flow that are required in itself is a guaranty that the unavoidable errors made in applying them are also small.

The instruments employed for making the current observations were:

1. Ellis meter, made by Buff & Berger, marked A.
2. Ellis meter, made by Buff & Berger, marked B.
3. Stackpole propeller meter, marked No. 1.
4. Stackpole propeller meter, marked No. III.

all of them provided with electrical recording attachment.

I abstain from a detailed description of the meters, as they are well known under the names given above and have been described numerous times in reports, handbooks, catalogues, etc. A good description accompanied by a cut of the Buff & Berger meter for instance, is found on page 307, Vol. II, of the Chief of Engineer's Report of 1875.

The rating of meters A, B, and III was done by moving them through still water at various rates of speed. The results obtained were expressed in the form of the well-known equation

$$y = a\,x + b$$

wherein

y = velocity of current in feet per second
x = number of revolutions per second

and a and b constants found from the process of rating by platting the results obtained, x (the number of revolutions) on the axis of abscisses and y (the velocities in feet per second) as ordinates. The points found render a straight line which intersects the axis

of ordinates at the distance b from the commencement of co-ordinates, and which incloses an angle x with the axis of abscisses, the tangent of which is equal to a. Besides this graphical method of finding a and b, the analytical method was employed as shown by the following table, into which the observations and values deduced from them were entered:

Rating of meter No. III.

R	Distance.	t	x	y	$x-x_0$	$y-y_0$	$(x-x_0)^2$	$(x-x_0)(y-y_0)$
		Seconds.						
186	300′	70.5	2.638	4.255	0.862	1.282	0.743	1.105
188	300′	64.5	2.915	4.651	1.139	1.676	1.299	1.913
185	300′	53.5	3.491	5.660	1.715	2.678	2.941	4.608
Etc.	Etc.	Etc.	Etc.	Etc.	Etc.	Etc.	Etc.	Etc.

wherein

R = total number of revolutions made by wheel on entire distance D traversed by meter.

x_0 = mean of all values of x.

y_0 = mean of all values of y.

From the final values taken from the foot of this table the constants were then computed according to the familiar equations:

$$a = \frac{\Sigma (x - x_0)(y - y_0)}{\Sigma (x - x_0)^2} \quad \text{and} \quad b = y_0 - x_0 a$$

The constants so found were the following:

For meter A: a=3.730, b=0.015.
For meter B: a=3,590, b=0.050.
For meter I: a=1.344, b=0.074.
For meter III: a=1.570, b=0.180.

The batteries used for recording the revolutions of the meter-wheel were the Grenet battery, consisting of two carbon and one zinc plates exposed to the action of a solution of bichromate of potash and sulphuric acid in water, the whole being contained in a single glass jar and made up very conveniently for transportation; and, secondly, Chester's electropion battery, which has a porous cell containing the carbon. The latter, being more constant, gave much better satisfaction than the former; but still better adapted for the same purpose is, I think, the Leclanché battery, with sealed porous cell, containing the carbon in water, while the zinc hangs in the glass jar, containing a saturated solution of sal-ammoniac.

The record of the wheel was given by an ordinary electric sounder or by a bell register inserted in the electric conduit. The general arrangement of the entire apparatus in the boat, the method of and the appliances for lowering and raising the meters, were substantially as described by Mr. Th. G. Ellis on pages 308 and 309 of the Chief Engineer's report for 1875. I will only add that the meter was always suspended from the bow of the boat, which was invariably headed against the current. As soon after turn of tide as the current was strong enough to swing the boat, the bow and stern lines by which it was anchored were shifted, the former to the stern and the latter to the bow in order to head the boat into the current again.

The plan followed during the work was to locate by means of instrumental observations from the shore points from 120 to 200 feet apart on each line which was to be gauged, and to observe at each of such points one practically complete ebb and flood. The observation was commenced at the surface, then the instrument was lowered to 3 feet below, then to 6 feet below, then to 9 feet, etc., until the bottom was reached, the duration of each observation generally being about one minute. After bottom had been reached the meter was hauled up, examined, and a new series of observations was commenced. The frequent examination of the meter was found to be of the utmost importance, in order to remove vegetable substances, weeds, etc., that would often wind themselves around the instrument in such a way as to impede its working. By commencing early in the morning and continuing till dark, it was generally possible to complete ebb and flood observations on one vertical in one day, and this would have been almost always the case if it had not been for the occasional interferences of fog, high winds, and accidents to the apparatus.

In this way in thirty-nine working days seven cross-sections were gauged, which are designated as follows:

A. Front River, immediately above Cross Tides.
B. Front River, immediately below King's Island.
C. Back River, below Recess.
D. South Channel, above month of St. Augustine Creek.
E. St. Augustine Creek, above railroad bridge.
F. North Channel, at Spirit Beacon.
G. Duck puddle.

On these seven cross-sections, the locations of which are shown on sheet No. 1, 50 verticals were located and about 15,700 single observations taken. The cross-sections themselves, as developed from the soundings taken on them, are shown on sheets No. 15 and No. 16 (looking down stream) where also the location and the designation of each gauged vertical are entered.

The notes during observations were made according to the following schedule:

May 16. *Meter I.* *Vertical* 7. *Line F.*

Time, p. m.	Depth below surface.	Duration of observation.	Observed number of revolutions.	Direction.	Computed velocity in feet per second.	Wind.
h.		*m. s.*				
3 48	1.0	0 40	59	Ebb.	2.056	S. E.
3 50	3.0	0 40	65	do.	2.258	Moderate.
3 51	6.0	0 40	55	do.	1.922	
Etc.	Etc.	Etc.	Etc.	Etc.	Etc.	

Before proceeding with the discussion of the further treatment of the field-notes it appears appropriate to insert here the notation adopted for the precise designation of the various quantities that will be dealt with. This system of notation has been constructed in analogy to the one given by Humphreys and Abbot in their work on the Mississippi gaugings and with a view to adapt the same to tidal flow.

a = area of mean low-water cross-section.
a_f = average of mean flood inflow.
a_e = average area of mean ebb outflow.
p = length of wetted perimeter.
$r = \frac{a}{p}$ = mean hydraulic radius.
$Q = \begin{cases} \text{mean ebb discharge in cubic feet per second.} \\ \text{mean flood inflow in cubic feet per second.} \end{cases}$
$v = \frac{Q}{a}$ = mean velocity.
D = depth of river at any given point.
$\triangle$ = maximum of mid-channel depth.

All velocities designated by V are mean velocities of the entire duration of either ebb or flood flow, the depth at which they exist being indicated by a right-hand and lower index, as follows:

V_0 = mean surface velocity at a given point.
V_2^D = mean mid-depth velocity at a given point.
V_D = mean bottom velocity at a given point.
V_m = mean of the mean velocities of a given vertical.

The upper index m indicates the mean of all the mean velocities across the width of the river, as follows:

V_0^m = Mean of mean surface velocities of cross-section.
$V_{\frac{D}{2}}^m$ = Mean of mid-depth velocities of cross-section.
V_D^m = Mean of mean bottom velocities of cross-section.
V_m^m = Mean of all V_m found in a cross-section.
D_m = depth, in fraction of total depth, at which V_m is found.

All velocities designated by C are velocities at the time of either ebb or flood maximum current, the further designation by indices remaining the same as before.

C_0 = Surface velocity at a given point at maximum current.
C_2^D = Mid-depth velocity at a given point at maximum current.
C_D = Bottom velocity at a given point at maximum current.
C_m = Mean velocity of a given vertical at maximum current.

The addition of the upper index m has the same meaning as before.

All velocities designated by U are the greatest velocities existing in a cross-section at the time of either ebb or flood maximum current.

U_0=Greatest surface velocity of cross-section at time of maximum current.

U_D=Greatest bottom velocity of cross-section at time of maximum current.

3. THE COMPUTATIONS OF EBB AND FLOOD VOLUMES.

The velocities found from the field-notes were platted, as shown on Sheet No. 17, the ebb velocities upwards, the flood velocities downward from a horizontal zero line, so that we obtain for each depth at which observations were made a double diagram, in which the area inclosed by the upper curve and the zero line represents the entire distance traveled by the ebb, while the lower area represents the entire distance traveled by the flood. In this way the results of the field work were platted on about fifty sheets (cross-section paper being used), containing about two hundred and eighty flood and as many ebb curves, all of which are herewith submitted. The areas of all these diagrams, or the lengths of flow represented by them, have been computed and are given for each successive point of depth on each vertical in a set of tables appended hereto and designated:

A.—"Observed durations and length of flow." In the same table will be found, at the foot of the column, the "mean length of flow" for each vertical, and the product of this figure, and the portion of the cross-sectional area pertaining to the vertical (compartment), is the volume of flow of that part of the entire cross-section.

The area of the compartment pertaining to each vertical may be considered to consist of two portions, viz, that below the mean low-water line and that above the same. The first is a constant and is easily found from the plats of cross-sections on sheets 15 and 16 by drawing a dividing line half way between each two verticals. The latter is variable and depends upon the average elevation of surface above mean low water during ebb and during flood flow of the observed tide. In order to determine this the tidal curve was platted (as shown by way of an example on Sheet No. 18) for each tide during which current observations were made, and from the gauge-readings taken at a point close to where the current was being measured. On the tidal curve thus drawn the mean low-water line was shown, and the times of change of current, as taken from the velocity diagrams (Sheet No. 17), were entered. Then the average of the flood ordinates and of the ebb ordinates was simply computed by a process of addition and division, as clearly shown on sheet 18. The height thus found, multiplied by the width of the compartment, then rendered the amount to be added to the portion of the compartment below mean low water in order to obtain its entire area. In this way thirty-five full tidal curves were platted and the mean elevation of surface for flood and for ebb outflow found from them, all of which diagrams are submitted herewith. The areas of compartments thus determined are entered in column three of a second set of tables appended hereto and headed:

B.—Volumes of flow and mean velocities (V_m) as corrected to mean tidal conditions.

At their side, in column 4, are entered the mean lengths of flow, and in column 5 the corrections for tide, which was obtained by taking the proportion of mean rise and fall to rise or fall on date. The product of these three items, as given in column 6, is the tidal flow corrected to mean tidal conditions and to the whole volume of this for the entire cross-section the correction for fresh-water flow is applied, the quotient of the corrected volume by the uncorrected one rendering the factor of correction for fresh-water flow to be applied to all velocities in order to reduce them to mean conditions of fresh-water flow.

In column 8 the cross-sectional area of mean ebb and flood flow (a_e and a_f) is given, which was found by applying a similar process as the one described above to the mean tidal curve. Column 9 gives the duration of mean flow, found by taking from the velocity diagrams (sheet 17) the average length of time high and low water slack at each vertical, is later than high and low water stand, and by applying this difference to the mean duration of rise and fall. The quotient:

$$\frac{\text{Volume of flow}}{(\text{mean } a_e \text{ or } a_f)\ (\text{mean duration})}$$

now renders mean velocity, V_m, under mean tidal conditions, and this, which is recorded in column 10, divided V_m on date renders a factor of corrections for tide, to be applied to all velocities observed during the flow to which it pertains, in order to reduce them to mean tidal conditions.

We therefore obtain from tables B two factors of correction, one for the fresh-water flow and one for height or volume of tide, by the product of which all velocities actually observed are multiplied in order to reduce them to mean conditions of tide and of fresh-water flow. The mean velocities V and the maximum velocities C

existing at the various depths have been so treated, and are platted on sheets 19–24, which will be referred to further below.

The ebb and flood volumes, as obtained at each cross-section and corrected to tide, are as follows:

Line.	Ebb volume.	Flood volume.
	Cubic feet.	*Cubic feet.*
A	931, 686, 676	103, 723, 621
B	565, 393, 642	129, 734, 238
C	189, 914, 877	104, 495, 718
D	748, 674, 038	428, 193, 437
E	336, 493, 404	289, 329, 116
F	1, 023, 250, 911	732, 221, 302
G	73, 703, 987	87, 928, 216

From the records of the gauge at Augusta it was found that the conditions of fresh-water flow existing at the time the various lines were gauged, were as follows:

Line.	Reading of gauge at Augusta.	Consequently as compared with mean fresh-water flow. Cubic feet per second.	
		Excess.	Deficiency.
A	10.5	2, 500	.....
B	9.2	.....	1, 700
C	15.0	12, 300	.....
D	9.2	.....	1, 700
E	9.0	.....	2, 150
F	8.0	.....	4, 300
G	8.5	.....	3, 200

From a careful consideration of the relative size of the various channels and the volumes of flow it was estimated that the percentage of the full excess or deficiency to be applied to each should be as follows:

Line A. The full excess to be applied.
Line B. Two-thirds of deficiency to be applied.
Line C. One-twelfth of excess to be applied.
Line D. Three-sevenths of deficiency to be applied.
Line E. One-fifty of deficiency to be applied.
Line F. Four-sevenths of deficiency to be applied.
Line G. One-twentieth of deficiency to be applied.

These figures, in connection with the mean duration of flow (see Table B), render the following corrections to be applied to the volumes as found above:

Line.	Ebb correction.	Flood correction.
	Cubic feet.	*Cubic feet.*
A	−75, 750, 000	+36, 000, 000
B	+33, 462, 000	−15, 708, 000
C	−24, 540, 000	+29, 160, 000
D	+19, 710, 000	−13, 815, 000
E	+ 9, 804, 000	− 9, 417, 000
F	+62, 769, 000	−46, 746, 000
G	+ 3, 600, 000	− 3, 552, 000

By means of these correction figures we now find the true volumes of ebb and flood flow, as corrected to mean conditions of tide and of fresh water, as follows:

Line.	True ebb volume.	True flood volume.
	Cubic feet.	*Cubic feet.*
A	855, 936, 676	139, 723, 621
B	598, 855, 642	114, 026, 238
C	165, 374, 877	124, 655, 718
D	768, 384, 038	414, 378, 437
E	346, 297, 404	279, 912, 116
F	1, 086, 019, 911	685, 475, 302
G	77, 303, 987	84, 376, 216

As these results form the basis of almost all further discussion it is of vital importance that their corrections should be tested by all possible means before advancing any further. For this purpose the following methods are available:

1. The difference between ebb and flood volume at the upper lines A and C, which is the volume of fresh-water flow there, should be practically equal to the same difference at the lower lines D, F, and G, there being no important tributary between the two systems of lines and the distance between them being only about 11 miles.

2. The sum of the tidal prism inclosed between the lower and the upper lines and the volume of flow at the latter should be equal to the volume of flow at the lower lines.

3. Comparison with the results of gauging made in 1878 and 1879.

4. THE FIRST AND THE SECOND METHOD OF CHECKING THE PRESENT RESULTS OF GAUGING.

The first check is easily made by applying direct the true volume as given above The result is as follows:

	Cubic feet.
Total of ebb volume at lines A and C	1, 021, 311, 553
Total of flood volume at lines A and C	264, 379, 339
Difference or volume of fresh-water flow	756, 932, 214
Total of ebb volume at lines D, F, and G	1, 931, 707, 936
Total of flood volume at lines D, F, and G	1, 184, 229, 955
Difference or volume of fresh-water flow	747, 477, 931

The difference between the two volumes of fresh-water flow is somewhat more than 1 per cent., a result much more exact than could have been expected.

Another comparison, however, should be made here, which is less favorable to our results. The mean of both volumes found above is 752,205,097 cubic feet, which represents the entire fresh-water flow during half a lunar day equal to $12^h\ 25^m = 44{,}700$ seconds. We therefore have, for the vicinity of Savannah, fresh-water flow per second, 16,828 cubic feet. Now the area of the river basin above Augusta is about 7,300 square miles and that below Augusta about 3,200 square miles; assuming an annual rain-fall of 48 inches, and disregarding for the moment being evaporations and absorptions, this would render a flow of—

At Augusta, 25,814 cubic feet per second.

At Savannah, 37,129 cubic feet per second.

Assuming, now, 50 per cent. evaporations and absorptions above Augusta and 55 per cent. in the entire basin, then we obtain—

Actual flow at Augusta, 12,907 cubic feet per second;

Actual flow at Savannah, 16,708 cubic feet per second;

a result comparing well with what we found for Savannah, but indicating that our mean flow for Augusta has been assumed too low. While computations of this kind necessarily are not overreliable, yet in this case the indisputable fact remains that the increase in the fresh-water flow experiences between Augusta and Savannah, as deduced from our current observations, is somewhat too large as compared with the inferences that must be drawn from the relative size of the upper and the lower river basins.

Proceeding to the second method of checking our meter results the following points have to be considered: Supposing that all tidal events took place simultaneously at

an upper and a lower point, and further, that change of current everywhere happened at the time of high, respectively low-water stand, then it is clear that the ebb flow at the lower point not only voided the tidal prism situated between both points, but in addition to that carried off the amount poured into such prism by the upper ebb flow. Likewise the lower flood flow not only filled the tidal prism, but in addition to that furnished the amount drained out of it by the upper flood flow.

If we designate as follows :

E^1 = volume of lower ebb flow.
F^1 = volume of lower flood flow.
E^u = volume of upper ebb flow.
F^u = volume of upper flood flow.
P = volume of tidal prism.

then the above facts may be expressed in these equations·

$$E^1 = E^u + P.$$
$$F^1 = F^u + P.$$

But as is well known matters in reality are not as simple as supposed here. Tidal events do not take place simultaneously at an upper and a lower point, but they happen earlier at the latter than at the former. After the current has reversed below it continues to run in the old direction for some time above. Consequently during the first stages of the lower ebb current there still exists an upper flood current which assists in voiding the prism, and when the lower ebb current ceases to run the upper one still continues ; in other words, the lower ebb current was not called upon to carry off the entire upper ebb volume, but only a portion of it. Designating that part of the upper flood volume, which helped to void the prism by f, then we have to substitute $P - f$ instead of P in the above ebb equation, and designating that part of the upper ebb volume which the lower ebb current was not called upon to carry off by e, then we have to substitute $E^u - e$ instead of E^u in the same equation and it now assumes this form

(1) $$E^1 = P + E^u - f - e.$$

The two volumes of f and e play a similar part during the flood current, in the first stages of which at the lower point the current still runs ebb above and helps to fill the prism to the amount of e, and at the end of which below the current continues to run flood above, thus relieving the lower flood flow from furnishing the entire upper flood flow and only calling for that amount less f. We therefore have the flood equation :

(2) $$F^1 = P + F^u - f - e.$$

In regard to P, it should be added that it is not of course the prism contained between the mean high and the mean low water line, but that it is the prism contained between the two surfaces existing at the time of high and of low water slack at the lower point.

In order to determine f and e for lines A and C with reference to slackwater at the lower lines we find the following (expressed in hours after lunar transit):

Flood current at lower lines: $3^h\ 15^m$ to $8^h\ 30^m$;
Ebb current at lower lines: $8^h\ 30^m$ to $15^h\ 40^m$;

which represents a mean of lines D and F, line G having been left out of consideration on account of its small volume.

We further find from Table No. 1

High water { At line A: $8^h\ 37^m$.
At line C: $8^h\ 30^m$.

Low water { At line A: $16^h\ 29^m$ or $4^h\ 04^m$.
At line C: $16^h\ 20^m$ or $3^h\ 55^m$.

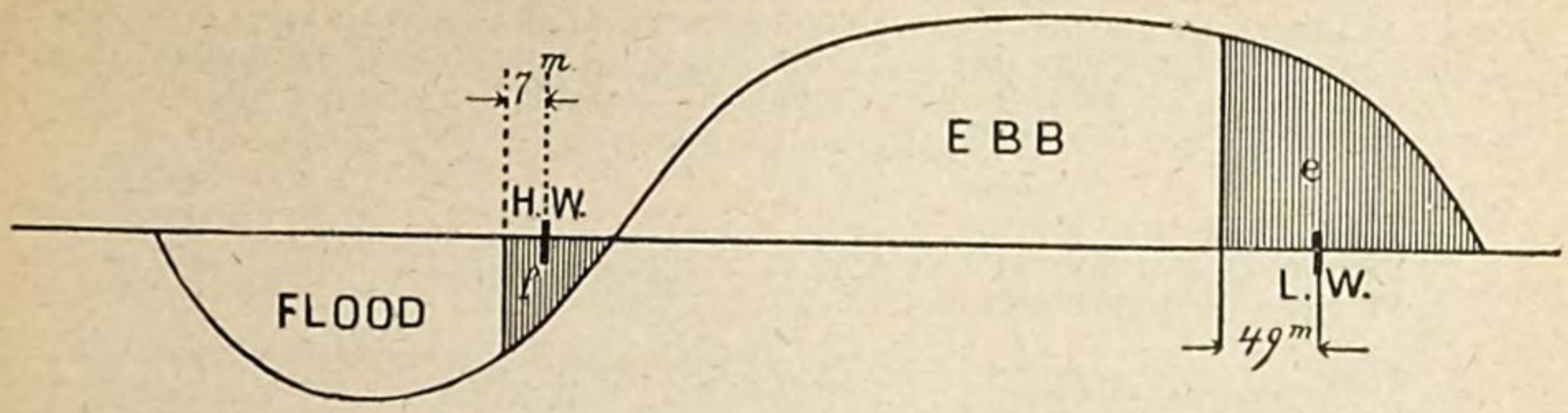
from which we see that the change of current at the lower lines takes place.

At line A { Forty-nine minutes before low-water stand.
Seven minutes before high-water stand.

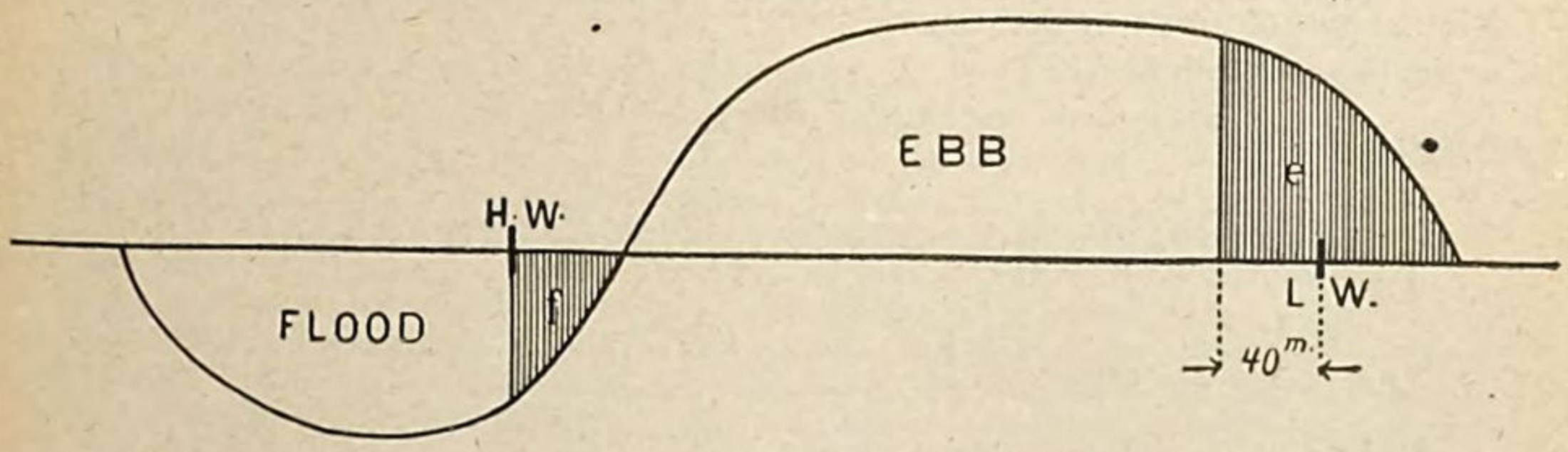
At line C { Forty minutes before low-water stand at time of high-water stand.

Entering all this information into the velocity diagrams of lines A and C we are now enabled without difficulty to compute e and f. The following two sketches give the data that were thus applied to the velocity diagrams, and show the extent of e and f

Velocity diagram at line A, showing *e* and *f*.



Velocity diagram at line C, showing *e* and *f*.



The volumes of *e* and *f* thus found and corrected to mean conditions of tide and of fresh-water flow were as follows:

		Cubic feet.
Line A	e =	154, 225, 700
	f =	8, 355, 000
Line C	e =	19, 478, 000
	f =	10, 062, 900
Total		192, 121, 600

The tidal prism contained between the upper and the lower lines was found by obtaining the area of river surface and multiplying the same with the height of tidal prism at the various places, which latter was found from a diagram of the surface lines as existing at the time of high-water slack and low-water slack at Spirit Island, or line F.

The results of these operations were as follows:

The tidal prism inclosed between lines A and C, and lines D, F, G, Savannah River.

Location.	Surface area.	Height of prism.	Volume of prism.
Front river:	*Square feet.*	*feet.*	*Cubic feet.*
Line A to Read's mill	17, 395, 600	4. 75	32, 629, 100
Read's mill to barge office	9, 781, 600	5. 60	54, 776, 960
Barge office to Fort Oglethorpe	12, 963, 200	6. 05	78, 427, 360
Fort Oglethorpe to lines D, F, and G	31, 908, 400	6. 00	191, 450, 400
Back river:			
Line C to cross-tides	11, 244, 288	6. 10	68, 590, 157
Cross-tides to main channel	75, 478, 256	6. 25	471, 739, 100
Total	158, 771, 344	.....	947, 613, 077

This, then, represents the volume of the tidal prism so far as the river surface proper is concerned. But the volume is further increased by the overflowed portions of the islands near line C, by King's Island, Marsh Island, Hutchinson's Island,

by lowlands on the Georgia shore, by Pipemaker Creek, Clydesdale Creek, Bilboa Canal, by the water-way between Hutchinson's and Fig Islands and by a number of ditches and rice canals, for all of which, according to as careful an estimate as could be made, about 100,000,000 cubic feet should be added to the above figure, rendering a total of, say, 1,050,000,000 cubic feet. Applying the values thus found for P, *e*, and *f* to the equations (1) and (2) we obtain:

Ebb:

	Cubic feet.
Tidal prism, P	1,050,000,000
Volume of ebb flow at line A	855,936,676
Volume of ebb flow at line C	165,374,877
Total	2,071,311,553
Less $(e + f)$ at lines A and C	192,121,600
Consequently volume of lower flow	1,879,189,953
Lower ebb flow as found by current observations at D, F, and G	1,931,707,936

A difference of about $2\frac{1}{4}$ per cent.

Again we obtain for the flood

Flood:

	Cubic feet.
Tidal prism, P	1,050,000,000
Volume of flood flow at A	139,723,621
Volume of flood flow at C	124,655,718
Total	1,314,379,339
Less $(e + f)$ at lines A and C	192,121,600
Consequently volume of lower flow	1,122,157,739
Lower flood flow as found by current observations at D, F, and G	1,184,229,955

A difference of about $5\frac{1}{4}$ per cent.

While the check on the flood volume is not as good as that on the ebb volume, they may both be accepted as fairly satisfactory, especially when it is considered that the discrepancy in both cases is in the same direction and would therefore be lessened if either the tidal prism had been computed too small or the sum of *e* and F too large.

A further check is obtained by comparison with the entire tidal prism of Savannah River, the upper part of which from lines A and C to the head of tide has been found as follows:

The tidal prism inclosed between lines H and C and the head of tide, Savannah River.

[Above Exchange, Savannah.]

Location.	Surface area.	Height of prism.	Volume of prism.
	Sqare feet.	*Feet.*	*Cubic feet.*
From A to 6-mile point	9,360,000	4.3	40,248,000
From 6-mile point to 8-mile point	23,475,600	4	93,830,000
From 8-mile point to 12-mile point	19,008,000	3.2	60,825,600
From 12-mile point to $15\frac{1}{2}$-mile point	12,384,000	2.4	29,721,600
From $15\frac{1}{2}$-mile point to 18-mile point	6,336,000	1.8	11,404,800
From 18-mile point to 23-mile point	8,064,000	1.1	8,870,400
From 23-mile point to 28-mile point	12,000,000	0.4	4,800,000
Collins and Abercorn Creek	7,500,000	1.8	13,500,000
Back River above line C	14,500,000	6	87,000,000
Lowlands above line A and C	10,000,000	4.5	45,000,000
Total	122,609,600	.....	295,200,400

In this table the mile points refer to City Exchange, Savannah.

If the result thus found is added to the volume of the lower prism found before, then we obtain for the entire tidal prism of Savannah River, above lines F, D, and G, and referred to the time of change of current at F:

$$P = 1{,}445{,}000{,}000 \text{ cubic feet.}$$

There being no tidal flow at the head of tide, *e* and *f* do not enter into the computation, and we only have to consider the fresh-water discharge at that place, during

the $7^h\ 13^m$ of ebb current and the $5^h\ 12^m$ of flood current at line F, which is as follows:

Discharge at head of tide during time of ebb current at line F = 25980 × 16500 = 428,670,000 cubic feet, and discharge at head of tide during time of flood current at line F = 18770 × 16500 = 308,880,000 cubic feet.

The operation of comparison, therefore, stands thus:

	Cubic feet.
Ebb:	
Entire tidal prism above lines F, D, and G	1,445,000,000
Fresh-water flow at head of tide	429,000,000
Consequently volume of flow at F, D, and G	1,874,000,000
Volume of flow at F, D, and G as actually found by current observations	1,932,000,000
Flood:	
Entire tidal prism above lines F, D, and G	1,445,000,000
Fresh-water flow at head of tide	309,000,000
Consequently volume of flow at F, D, and G	1,136,000,000
Volume of flow at F, D, and G as actually found by current observations	1,184,000,000

5. RESULTS OF 1879 AND THIRD METHOD OF CHECKING.

In May, 1879 (before the construction of Cross Tides Dam), the Savannah River was gauged at various points by Capt. J. C. Post, Corps of Engineers, U. S. Army and the results obtained are embodied in a report to General Q. A. Gillmore, of June 9, 1879. The following figures are copied from this report, rounded off to half millions:

	Ebb volume.	Flood volume.
	Cubic feet.	*Cubic feet.*
Above Cross Tides, Gibbons (above present line A)	601,000,000	221,500,000
At Cross Tides	477,500,000	210,000,000
Front River, Dr. Read (below present line B)	369,000,000	148,000,000
North Channel, Spirit Island (at present line F)	1,107,000,000	1,076,000,000
South Channel (at present line D)	629,000,000	599,500,000
Duck Puddle (at present line G)	35,500,000	142,500,000
North Channel, Long Island	2,421,500,000	1,890,000,000
South Channel, Long Island	402,000,000	407,000,000

The quantities given in the report have not been corrected to either tide or fresh-water flow, and in order to further discuss them this must therefore, first of all, be done. Without entering into the details of this operation, which has been made in precisely the same way as described above, it may be mentioned here that the corrections for tide on the whole were insignificant, while the corrections for fresh-water flow were considerable throughout, the gauge at Augusta having read from 5.5 to 6 feet during the time the observations were taken, which corresponds to a deficiency in fresh-water flow of 6,700 to 7,300 cubic feet per second. The ebb volumes were therefore found too small and the flood volumes too large.

Applying the necessary corrections to each of the above figures, we obtain the following volumes of ebb and of flood flow, corrected to mean conditions of tide and of fresh-water flow:

	Ebb volume.	Flood volume.
	Cubic feet.	*Cubic feet.*
Above Cross Tides, Gibbons	804,000,000	180,500,000
At Cross Tides	593,500,000	207,500,000
Front River at Read's	456,000,000	144,000,000
North Channel, Spirit Island (present F)	1,324,000,000	1,018,000,000
South Channel (present D)	774,000,000	554,000,000
Duck Puddle	109,000,000	131,000,000
North Channel, Long Island	2,605,000,000	1,833,000,000
South Channel, Long Island	444,000,000	390,500,000

The first three lines inclose a tidal prism of 70,000,000 cubic feet, and the application to them of equations (1) and (2) (neglecting $e + f$, which in this case is insignificant), renders:

EBB.

	Cubic feet.		*Cubic feet.*
Cross Tides	593,500,000	Gibbons	804,000,000
Read's	456,000,000	Tidal prism	70,000,000
Total	1,049,500,000	Total	874,000,000

FLOOD.

Cross Tides	207,500,000	Gibbons	180,500,000
Read's	144,000,000	Tidal prism	70,000,000
Total	351,500,000	Total	250,500,000

Correction now renders:

EBB.

	Cubic feet.		*Cubic feet.*
Cross Tides	544,000,000	Gibbons	892,000,000
Read's	418,000,000	Tidal prism	70,000,000
Total	962,000,000	Total	962,000,000

FLOOD.

Cross Tides	177,000,000	Gibbons	231,000,000
Read's	124,000,000	Tidal prism	70,000,000
Total	301,000,000	Total	301,000,000

The last five of the lines gauged in 1879 inclose a tidal prism of 790,000,000 cubic feet, and in this case the lower lines are so far removed from the upper ones that $e + f$ can not be neglected. It has been computed at—

	Cubic feet.
For North Channel, Spirit Island	60,000,000
For South Channel	45,000,000
Total	105,000,000

Furthermore, the flow through Augustine Creek has to be considered, which, as will be shown later on, reduces the ebb volume in South Channel by abont 300,000,000 cubic feet, and the flood volume by about 230,000,000 cubic feet. The operation therefore stands thus—

EBB.

	Cubic feet.		*Cubic feet.*
North Channel, Long Island	2,605,000,000	North Channel, Spirit Island	1,324,000,000
South Channel, Long Island	444,000,000	South Channel	774,000,000
		Duck Puddle	109,000,000
		Tidal prism	790,000,000
		Total	2,997,000,000
		Less $e+f$ =	105,000,000
		Less Augustine Creek =	300,000,000
			405,000,000
Lower flow	3,049,000,000	Lower flow	2,592,000,000

FLOOD.

North Channel, Long Island	1,833,000,000	North Channel, Spirit Island	1,018,000,000
South Channel, Long Island	390,500,000	South Channel	554,000,000
		Duck Puddle	131,000,000
		Tidal prism	790,000,000
		Total	2,493,000,000
		Less $e + f$ =	105,000,000
		Less Augustine Creek =	230,000,000
			335,000,000
Lower flow	2,223,500,000	Lower flow	2,158,000,000

Correction renders:

EBB.

	Cubic feet.		*Cubic feet.*
North Channel, Long Island	2,409,500,000	North Channel, Spirit Island	1,460,500,000
South Channel, Long Island	411,000,000	South Channel	848,500,000
		Duck Puddle	126,500,000
		Tidal prism	790,000,000
		Total	3,225,500,000
		Less $e+f$ =105,000,000	
		Less Augustine Creek =300,000,000	
			405,000,000
Lower flow	2,820,500,000	Lower flow	2,820,500,000

FLOOD.

North Channel, Long Island	1,806,000,000	North Channel, Spirit Island	1,038,000,000
South Channel, Long Island	385,000,000	South Channel	564,500,000
		Duck Puddle	133,500,000
		Tidal prism	790,000,000
		Total	2,526,000,000
		Less $e+f$ =105,000,000	
		Less Augustine Creek =230,000,000	
			335,000,000
Lower flow	2,191,000,000	Lower flow	2,191,000,000

We therefore now have the following corrected volumes:

	Ebb volume.	Flood volume.
	Cubic feet.	*Cubic feet.*
Above Cross Tides, Gibbons	892,000,000	231,000,000
At Cross Tides	544,000,000	177,000,000
Front River at Read's	418,000,000	124,000,000
North Channel, Spirit Island	1,460,500,000	1,038,000,000
South Channel	848,500,000	564,500,000
Duck Puddle	126,500,000	133,000,000
North Cbannel, Long Island	2,409,500,000	1,806,000,000
South Channel, Long Island	411,000,000	385,000,000

By taking the difference between ebb and flood flow the following results are obtained for fresh-water flow:

	Cubic feet.
At Gibbons	661,000,000
Cross Tides and Read's	661,000,000
North Channel, South Channel, Duck Puddle	699,000,000
North Channel, Long Island; South Channel, Long Island	629,500,000

In the light of our present investigations, the first two figures must be about 40,000,000 cubic feet too small, because Back River (line C) is not included, and the last figure must be about 66,000,000 too small, because Augustine Creek is not included. Making these corrections, our values found for fresh-water flow range from 695,000,000 to 701,000,000 cubic feet, thus agreeing well among themselves and fairly well with the amount found now (752,000,000 cubic feet).

If now the upper lines at Cross Tides and Read's are compared with the lower lines near Spirit Island in North and South Channel, and in Duck Puddle, inserting into the upper group the present volumes found at line C (where no gauging was done in 1879), then it becomes apparent that the volume of tidal prism between the upper and the lower systems as indicated by such comparison is about 500,000,000 cubic feet greater than the same volume as found by present computations, given above. It is, however, not likely that this difference is entirely due to an actual decrease of tidal range in the Lower Savannah, but the cause of its appearance must, doubtless, partially be sought in such circumstances as a possible greater area of overflowed lands at that time, or other reasons at present unknown. This explanation becomes all the more probable when a further group of lines is considered on which observations were made in 1879, and which is situated at the mouth of Bilboa Canal, about half-way between the upper and the lower group just discussed. The results as given in the report are:

	Ebb volume.	Flood volume.
	Cubic feet.	*Cubic feet.*
Front River, old line E D	506,500,000	331,500,000
Back River, old line E D	845,000,000	598,000,000

Correcting to mean conditions we obtain:

	Ebb volume.	Flood volume.
	Cubic feet.	*Cubic feet.*
Front River, old line E D	576, 500, 000	294, 000, 000
Back River, old line E D	950, 000, 000	546, 500, 000

The difference between ebb and flood flow renders 686,000,000 cubic feet, which agrees fairly well with the amounts found previously. Comparing with the upper flow, we have to consider a surface area of about 30,000,000 square feet in Front River and about 52,000,000 square feet in Back River, rendering a tidal prism of, say, 525,000,000 cubic feet, while $e+f$ may be fairly put at one-half the amount between line F and the upper lines; that is, at 96,000,000 cubic feet. We now find:

EBB.

	Cubic feet.		*Cubic feet.*
Front River, E D	576, 500, 000	Gibbons	892, 000, 000
Back River, E D	950, 000, 000	Line C	165, 000, 000
		Tidal prism	525, 000, 000
		Total	1, 582, 000, 000
		Less $e+f$	96, 000, 000
Lower flow	1, 526, 500, 000	Lower flow	1, 486, 000, 000

FLOOD.

Front River, E D	294, 000, 000	Gibbons	231, 000, 000
Back River, E D	546, 500, 000	Line C	124, 500, 000
		Tidal prism	525, 000, 000
		Total	880, 000, 000
		Less $e+f$	96. 000, 000
Lower flow	840, 000, 000	Lower flow	786, 000, 000

Having thus submitted internal evidence to the effect that the corrected results of 1879 for the upper lines can not be far from truth, we now proceed to compare them with our present ones, to do which they should be reduced to the same location. The old line at Gibbons was situated 1,000 feet above our present line A, while the old Read's mill line was situated 2,400 below our present line B. Between the former two there is an area inclosed of about 1,000,000 square feet, and between the latter two there is one of about 2,000,000 square feet, rendering tidal prisms of respectively, say, 6,000,000 and 13,000,000 cubic feet, the former of which has to be added to the results at Gibbons in order to reduce them to line A, and the latter of which has to be subtracted from the results at Read's Mill in order to reduce them to line B. In the following are given the results thus found, together with the results of 1889; regarding the latter, it should be mentioned that the computation of the volumes at present passing over Cross Tides Dam, which has not yet been given, will be found further below:

EBB.

	1879.	1889.
	Cubic feet.	*Cubic feet.*
At line A	898, 000, 000	856, 000, 000
At Cross Tides	544, 000, 000	295, 500, 000
At line B	405, 000, 000	599, 000, 000

FLOOD.

At line A	237, 000, 000	140, 000, 000
At Cross Tides	177, 000, 000	64, 000, 000
At line B	111, 000, 000	114, 000, 000

It will be seen that the former ebb volumes are somewhat larger than the present ones, which is in accordance with the facts of the tidal prism of Front River having been diminished through the construction of the dam. The flood flow through Cross Tides has diminished 113,000,000 cubic feet, while through line B it has increased 3,000,000 cubic feet, being a total decrease of 110,000,000. If this amount is deducted

from the former flood flow through line A, there remains 127,000,000 cubic feet, which is reasonably near the present flow.

Summing up, the final outcome of the various tests applied to our results may be stated as follows:

The test of difference between ebb and flood volume was corroborative as far as applied to the present results only. When, however, the volume of fresh-water flow as found in 1889 was compared with that deduced from the 1879 observations, then the former was found too great by about 1,000 cubic feet per second, a result that appears confirmed by considering the relative size of the river basin above Augusta and of the one below that place.

The comparison of upper and lower flow with the tidal prism, and the comparisons with the gaugings of 1879, verify the present results within fair limits, the greatest discrepancy for the flood flow being one of about 5 per cent. while the greatest discrepancy for the more important ebb flow is about 2 per cent. It appears from all this that the volumes found in 1889 are sufficiently near the truth to form a reliable basis of discussion.

6. VOLUMES OF FLOW DEDUCED FOR PLACES NOT ACTUALLY GAUGED.

From the volumes found by actual gauging we can determine by simple operations the volumes for cross-sections that were not gauged, and in the following this is done for the more important locations. The tidal prisms and the volumes of $e+f$, required for these operations, have been computed with care, but it has not been deemed necessary to repeat all these computations here.

The flow over Cross Tides Dam.

	Cubic feet.
Ebb:	
Ebb outflow at line A	855,936,676
Ebb outflow at line B	598,855,642
Difference	257,081,034
Tidal prism between lines A, B, and dam	38,536,960
Consequently ebb flow over dam into Back River	295,617,994
Flood:	
Flood inflow at line A	139,723,621
Flood inflow at line B	114,026,238
Difference	25,697,383
Tidal prism between lines A, B, and dam	38,536,960
Consequently flood flow over dam into Front River	64,234,343

Incidentally it may be remarked here that the computation of this volume by means of Kutter's formula renders almost precisely the same result. The known quantities are:

Mean cross-sectional area during flood	square feet	2,460
Width of cross-section	feet	800
Consequently mean depth, R	do	3.1
Distance between upper and lower gauge	do	350
Average difference of elevation of surface during flood flow, as found from these gauges	do	0.17
Consequently S (surface slope)		0.00049

Now, if n, the co-efficient of roughness, is assumed at 0.35, then c becomes 51, and we find

$$v=51\sqrt{3.1\ (0.00049)}=1.989$$

The duration of flow, according to the duration of flood slope, must be abont $3^h\ 40^m$, and we consequently find the volume at $1.989\times2,460\times13,200=64,587,600$ cubic feet.

A similar computation for the ebb volume can not be made, because during a great part of the ebb flood there is an overfall at the dam.

In computing the flow in South Channel below St. Augustine Creek it must be remembered that $e+f$ here have to be inserted additive into equations (1) and (2), because the direction of ebb and flood in the creek must be looked upon as opposite to that in South Channel, as far as the filling and the voiding of the tidal prism is concerned.

We find the following:

The flow in South Channel below St. Augustine Creek.

Ebb:	Cubic feet.
Ebb outflow at line D	768, 384, 038
$(e+f)$ for Augustine Creek	46, 000, 000
	814, 384, 038
Ebb outflow of St. Augustine Creek	346, 297, 404
Consequently ebb outflow in South Channel below Augustine Creek	468, 086, 634
Flood:	
Flood inflow at line D	414, 378, 437
$(e+f)$ for Augustine Creek	46, 000, 000
	460, 378, 437
Flood inflow of St Augustine Creek	279, 912, 116
Consequently flood flow in South Channel below Augustine Creek	180, 466, 321

In order to get from the volumes found here the true volume of flow at any particular point of South Channel the amount of the tidal prism contained between such point and line D must be added and the volume of $(e+f)$ for line D must be subtracted.

It may be remarked here incidentally that the above figures clearly show the existence of a connection between St. Augustine Creek and Savannah River, to be detrimental to the latter. The flow in South Channel below the mouth of St. Augustine Creek is weakened almost to the entire amount of the flow in the creek.

From the figures found above the flow at the lower end of South Channel is determined as follows:

The flow at lower end of South Channel near mouth of Lazaretto Creek.

Ebb:		Cubic feet.
Ebb outflow below Augustine Creek as found		468, 086, 634
Tidal prism between D and Lazaretto Creek		550, 000, 000
		1, 018, 086, 634
Estimated ebb outflow through "Gaps"	60, 000, 000	
$(e+f)$ at line D	90, 000, 000	
		150, 000, 000
Consequently ebb outflow at lower end South Channel		868, 086, 634
Flood:		
Flood inflow below Augustine Creek, as found		180, 466, 321
Tidal prism between D and Lazaretto Creek		550, 000, 000
		730, 466, 321
Estimated flood inflow through "Gaps"	160, 000, 000	
$(e+f)$ at line D	90, 000, 000	
		250, 000, 000
Consequently flood inflow at lower and South Channel		480, 466, 321

The flow in the lower part of North Channel, not including the unknown flow of Wrights River, is found as follows:

The flow in North Channel at Oyster Bed Beacon.

Ebb:	Cubic feet.
Ebb outflow on lines F and G	1, 163, 323, 898
Estimated ebb flow through the "Gaps"	60, 000, 000
Tidal prism between lines F and Oyster Bed Beacon	990, 000, 000
	2, 213, 323, 898
$(e+f)$ at line F	180, 000, 000
Consequently ebb outflow at Oyster Bed Beacon	2, 033, 323, 898

Flood:	Cubic feet.
Flood inflow on lines F and G	769,851,518
Estimated flood flow through the "Gaps"	160,000,000
Tidal prism between F and Oyster Bed Beacon	990,000,000
	1,919,851,518
$(e+f)$ at line F	180,000,000
Consequently flood inflow at Oyster Bed Beacon	1,739,851,518

7. DISCUSSION OF MEAN AND MAXIMUM VELOCITIES.

In order to obtain an insight into the various relations of velocities to each other the following set of tables, marked C, has been prepared. The mid-depth and the bottom velocity have been taken from the diagrams, sheets 19 to 24, the vertical velocity curve always having been drawn in what appeared the most probable way. All velocities are corrected to mean conditions of tide and of fresh-water flow.

C.—Tables of velocities and the relations between them.

LINE A. EBB. R = 10.8.

Vertical.	V_m	d_m	$V_{\frac{D}{2}}$	$\frac{V_{\frac{D}{2}}}{V_m}$	V_D	C_m	$C_{\frac{D}{2}}$	$\frac{C_{\frac{D}{2}}}{C_m}$	C_D	$\frac{C_D}{V_m}$	U_D	$\frac{U_D}{v}$
1*a*	1.63	0.644	1.85	1.135	0.50	2.07	2.45	1.184	0.90	0.552	.....	.....
11	2.27	0.691	2.33	1.026	2.00	2.95	2.93	0.993	2.75	1.211	2.75	1.900
2*a*	1.78	0.549	1.78	1.000	1.40	2.24	2.23	0.996	1.90	1.067	1.90	1.310
12	1.33	0.633	1.45	1.090	0.60	1.84	2.00	1.087	1.00	0.752	.....	.....
4	1.38	0.536	1.40	1.015	1.00	1.99	2.04	1.025	1.60	1.160	.....	.....
5	1.20	0.611	1.35	1.125	0.90	1.70	1.85	1.088	1.35	1.125	.....	.....
6	1.26	0.581	1.30	1.032	1.10	1.64	1.68	1.024	1.45	1.151	.....	.....
7	0.76	0.526	0.80	1.052	0.70	0.99	1.00	1.010	0.85	1.118	.....	.....
8	0.67	0.769	0.70	1.045	0.60	0.99	1.00	1.010	0.80	1.194	.....	.....
9	1.24	0.629	1.30	1.048	0.90	1.70	1.80	1.060	1.35	1.089	.....	.....
10	0.83	0.620	0.83	1.000	0.60	1.14	1.22	1.070	0.85	1.024	.....	.....
Mean ..	1.30	0.617	1.37	1.052	0.94	1.75	1.84	1.050	1.35	1.040	.....	.....

$v = 1.45.$

LINE A. FLOOD. R = 12.2.

1*a*	0.51	0.642	0.57	1.118	0.10	0.62	0.70	1.130	0.10	0.196	.....	1.935
11	0.93	0.576	0.94	1.011	0.73	1.57	1.62	1.032	1.20	1.290	1.20	.....
12	0.49	0.564	0.52	1.061	0.17	0.80	0.90	1.125	0.30	0.612	.....	.....
4	0.71	0.567	0.77	1.085	0.23	1.06	1.15	1.085	0.55	0.714	.....	.....
5	0.52	0.553	0.55	1.058	0.25	0.77	0.80	1.039	0.40	0.770	.....	.....
6	0.53	0.526	0.52	0.981	0.35	0.68	0.68	1.000	0.50	0.945	.....	.....
7	0.33	0.686	0.35	1.061	0.15	0.48	0.55	1.146	0.30	0.909	.....	.....
8	0.37	0.710	0.40	1.081	0.27	0.57	0.62	1.088	0.40	1.081	.....	.....
9	0.70	0.573	0.75	1.071	0.35	1.02	1.06	1.039	0.70	1.000	.....	.....
10	0.37	0.595	0.37	1.000	0.25	0.48	0.47	0.980	0.30	0.811	.....	.....
Mean ..	0.55	0.599	0.57	1.053	0.29	0.81	0.86	1.066	0.48	0.833		

$v = 0.62.$

LINE B. EBB. R = 11.2.

1	1.65	0.615	1.75	1.061	1.10	2.11	2.25	1.066	1.75	1.061	.....	.....
2*a*	2.47	0.654	2.62	1.061	1.90	3.23	3.40	1.052	2.70	1.093	.....	.....
3	2.46	0.617	2.57	1.045	1.90	3.27	3.25	0.994	2.75	1.118	2.75	1.268
4	2.34	0.634	2.36	1.009	1.90	3.13	3.20	1.022	2.75	1.175	.....	.....
5	2.30	0.660	2.45	1.065	1.45	3.07	3.20	1.043	2.40	1.043	.....	.....
6	2.21	0.699	2.37	1.072	1.50	2.78	3.93	1.058	2.30	1.041	.....	.....
7	1.66	0.685	1.82	1.096	1.17	2.08	2.28	1.096	1.60	0.964	.....	.....
Mean ..	2.15	0.652	2.28	1.058	1.56	2.81	2.93	1.048	2.32	1.071	.....	.....

$v = 2.17.$

C.—*Table of velocities and the relations between them*—Continued.

LINE B. FLOOD. R=12.9.

Vertical.	V_m	d_m	$V_{\frac{D}{2}}$	$\frac{V_{\frac{D}{2}}}{V_m}$	V_D	C_m	$C_{\frac{D}{2}}$	$\frac{C_{\frac{D}{2}}}{C_m}$	C_D	$\frac{C_D}{V_m}$	U_D	$\frac{U_D}{v}$
1.....	0.60	0.515	0.62	1.033	0.30	0.86	0.90	1.046	0.40	0.666	.....	.....
2*a*.....	0.87	0.600	0.90	1.034	0.68	1.28	1.28	1.000	1.05	1.207	1.05	1.364
3.....	0.74	0.582	0.78	1.054	0.50	1.11	1.20	1.081	0.70	0.946	.....	.....
4	0.74	0.583	0.77	1.041	0.50	1.07	1.10	1.028	0.70	0.946	.....	.....
5.....	0.80	0.644	0.85	1.062	0.56	1.15	1.20	1.043	0.85	1.062	.....	.....
6.....	0.76	0.691	0.80	1.053	0.55	1.08	1.12	1.037	0.75	0.987	.....	.....
7.....	0.76	0.612	0.80	1.053	0.55	1.11	1.14	1.027	0.80	1.052	.....	.....
Mean ..	0.77	0.604	0.79	1.047	0.52	1.09	1.13	1.037	0.75	0.981	.....	.....

$v = 0.77.$

LINE C. EBB. R=11 . 0.

1.....	1.54	0.651	1.70	1.104	1.00	1.98	2.10	1.061	1.45	0.942	.....	.....
2.....	1.46	0.735	1.55	1.062	1.05	1.86	1.95	1.048	1.50	1.027	1.50	1.154
3.....	1.14	0.559	1.20	1.052	0.78	1.52	1.58	1.039	1.10	0.965	.....	.....
4.....	0.60	0.571	0.60	1.000	0.50	0.83	0.85	1.024	0.60	1.000	.....	.....
Mean ..	1.18	0.629	1.26	1.054	0.83	1.55	1.62	1.043	1.16	0.984	.....	.....

$v = 1.30.$

LINE C. FLOOD. R=12.7.

1.....	0.88	0.707	1.04	1.182	0.20	1.18	1.40	1.187	0.45	0.511	.....	.....
2.....	1.10	0.679	1.17	1.064	0.74	1.50	1.58	1.053	0.90	0.818	.....	.....
3.....	1.16	0.610	1.20	1.035	0.90	1.53	1.55	1.013	1.05	0.905	1.05	1.020
4.....	0.94	0.434	0.93	0.989	0.74	1.32	1.28	0.970	1.05	1.117	.....	.....
Mean ..	1.02	0.[illegible]05	1.08	1.067	0.64	1.38	1.45	1.056	0.86	0.838	.....	.....

$v = 1.03.$

LINE D. EBB. R=12.3.

1	0.74	0.521	0.74	1.000	0.62	1.02	1.05	1.029	0.80	1.081	.....	.....
2.....	1.13	0.568	1.13	1.000	0.90	1.47	1.50	1.020	1.20	1.062	.....	.....
3.....	1.30	0.523	1.32	1.015	0.82	1.75	1.85	1.057	1.30	1.000	.....	.....
4.....	1.47	0.531	1.46	0.994	1.08	2.02	2.10	1.040	1.60	1.088	.....	.....
5.....	1.55	0.610	1.65	1.065	1.00	2.17	2.30	1.060	1.65	1.064	.....	.....
6.....	1.74	0.573	1.80	1.031	1.25	2.44	2.56	1.049	1.90	1.092	.....	.....
7.....	2.90	0.567	1.98	1.042	1.20	2.73	2.90	1.063	1.85	0.974	.....	.....
8.....	2.06	0.623	2.18	1.958	1.60	2.87	2.98	1.038	2.10	1.019	2.10	1.288
9.....	1.53	0.730	1.70	1.111	1.10	2.42	2.52	1.041	1.60	1.045	.....	.....
Mean ..	1.49	0.583	1.55	1.035	1.06	2.10	2.20	1.044	1.56	1.047	.....	.....

$v = 1.63.$

LINE D. FLOOD. R=14.3.

1.....	0.83	0.441	0.80	0.940	0.64	1.20	1.18	0.983	0.90	1.084	.....	.....
2.....	1.03	0.532	1.05	1.020	0.68	1.56	1.57	1.007	1.00	0.970	.....	.....
3.....	1.01	0.472	1.00	0.990	0.70	1.60	1.60	1.000	1.20	1.189	.....	.....
4.....	0.94	0.511	0.97	1.032	0.62	1.46	1.44	0.979	1.10	1.170	.....	.....
5.....	0.94	0.559	1.00	1.064	0.57	1.46	1.52	1.041	0.95	1.011	.....	.....
6.....	1.06	0.593	1.10	1.038	0.70	1.55	1.60	1.032	1.10	1.038	.....	.....
7.....	1.13	0.610	1.17	1.035	0.68	1.67	1.70	1.018	1.10	0.974	.....	.....
8.....	1.43	0.580	1.45	1.014	1.00	2.11	2.17	1.028	1.40	0.979	1.40	12.69
9.....	1.16	0.707	1.32	1.138	0.67	1.77	1.95	1.102	1.00	0.862	.....	.....
Mean ..	1.06	0.556	1.10	1.030	0.70	1.60	1.64	1.021	1.08	1.031	.....	.....

$v = 1.08.$

C.—*Tables of velocities and the relations between them*—Continued.

LINE E. EBB. R = 18.9.

Vertical.	V_m	d_m	$V_{\frac{D}{2}}$	$\frac{V_{\frac{D}{2}}}{V_m}$	V_D	C_m	$C_{\frac{D}{2}}$	$\frac{C_{\frac{D}{2}}}{C_m}$	C_D	$\frac{C_D}{V_m}$	U_D	$\frac{U_D}{v}$
1.....	1.09	0.643	1.20	1.101	0.70	1.72	1.70	0.988	1.25	1.147	.....	.....
2.....	1.61	0.622	1.75	1.087	0.80	2.14	2.20	1.028	1.15	0.714	.....	.....
3.....	1.71	0.615	1.90	1.111	0.70	2.50	2.60	1.040	1.45	0.848	.....	.....
4.....	1.80	0.569	1.96	1.089	0.85	2.71	2.90	1.070	1.70	0.944	1.70	1.056
Mean ..	1.55	0.608	1.70	1.097	0.76	2.27	2.35	1.031	1.39	0.913	.....	.....

$v = 1.61.$

LINE E. FLOOD. R = 20.9.

1.....	0.88	0.659	1.00	1.136	0.50	1.17	1.26	1.080	0.85	0.966	.....	.....
2.....	1.40	0.546	1.40	1.000	0.75	1.90	2.05	1.080	1.25	0.900	.....	.....
3.....	1.37	0.648	1.48	1.080	0.92	1.82	1.90	1.044	1.65	1.204	1.65	1.352
4.....	1.02	0.636	1.08	1.059	0.60	1.43	1.60	1.119	0.65	0.637	.....	.....
Mean ..	1.17	0.613	1.24	1.069	0.69	1.58	1.70	1.081	1.10	0.927	.....	.....

$v = 1.22.$

LINE F. EBB. R = 20.1.

1.....	1.16	0.556	1.33	1.147	0.75	1.74	1.83	1.052	1.35	1.164	.....	.....
2.....	1.43	0.606	1.50	1.049	1.00	1.89	1.97	1.042	1.40	0.979	.....	.....
3.....	1.63	0.645	1.70	1.043	1.12	2.27	2.35	1.079	1.75	1.074	.....	.....
4.....	1.80	0.659	1.95	1.083	1.15	2.48	2.60	1.048	2.00	1.111	2.00	1.136
5.....	1.81	0.586	1.92	1.061	0.95	2.55	2.80	1.098	1.50	0.829	.....	.....
6.....	2.05	0.566	2.11	1.029	1.12	2.77	2.95	1.065	1.75	0.854	.....	.....
7.....	1.84	0.612	1.91	1.038	1.25	2.47	2.60	1.052	1.80	0.978	.....	.....
8.....	1.58	0.594	1.60	1.013	1.30	1.98	2.06	1.040	1.70	1.076	.....	.....
Means .	1.66	0.603	1.75	1.058	1.08	2.27	2.40	1.060	1.66	1.008	.....	.....

$v = 1.76.$

LINE F. FLOOD. R = 21.8.

1	1.01	0.563	1.05	1.040	0.70	1.35	1.38	1.022	1.00	0.990	.....	.....
2.....	1.27	0.626	1.35	1.063	0.90	1.90	1.90	1.000	1.45	1.142	.....	.....
3.....	1.70	0.510	1.70	1.000	1.32	2.53	2.52	0.996	2.10	1.235	2.10	1.522
4.....	1.57	0.589	1.68	1.070	1.04	2.45	2.62	1.069	1.60	1.019	.....	.....
5.....	1.36	0.648	1.50	1.103	0.82	1.98	2.15	1.086	1.30	0.956	.....	.....
6.....	1.39	0.709	1.53	1.101	0.80	1.96	2.08	1.061	1.30	0.935	.....	.....
7.....	1.29	.....	1.32	1.023	0.80	1.79	1.85	1.034	1.35	1.047	.....	.....
8.....	1.18	0.569	1.27	1.076	0.65	1.52	1.55	1.020	1.10	0.932	.....	.....
Means.	1.35	0.602	1.42	1.060	0.88	1.94	2.01	1.036	1.40	1.032	.....	.....

$v = 1.38.$

LINE G. EBB. R = 5.9.

1.....	1.34	0.641	1.40	1.045	1.00	2.09	2.15	1.029	1.75	1.306	1.75	1,509
2.....	1.34	0.507	1.33	0.970	0.96	2.05	2.08	1.015	1.70	1.269	.....	.....
3.....	1.05	0.533	1.08	1.029	0.70	1.71	1.75	1.024	1.05	1.000	.....	.....
4.....	0.76	0.600	0.80	1.052	0.50	1.54	1.62	1.052	1.30	1.711	.....	.....
Means.	1.12	0.570	1.13	1.024	0.79	1.85	1.90	1.030	1.45	1.321	.....	.....

$v = 1.16.$

LINE G. FLOOD. R = 7.5.

1.....	0.93	0.660	1.00	1.075	0.50	1.54	1.70	1.104	0.80	0.860	.....	.....
2.....	1.25	0.600	1.25	1.000	0.85	1.97	2.00	1.015	1.25	1.000	.....	.....
3.....	1.00	0.467	1.00	1.000	0.80	1.94	1.96	1.010	1.65	1.650	1.65	1,636
4.....	0.84	0.462	0.85	1.012	0.65	1.64	1.66	1.012	1.20	1.429	.....	.....
Means .	1.01	0.547	1.02	1.022	0.70	1.77	1.83	1 035	1.22	1.235	.....	.....

$v = 1.01$

The more interesting of the results of these tables are presented in a condensed form as follows:

EBB.

Location.	v	d_m	$V^m_{\frac{D}{2}}$	$\frac{V^m_{\frac{D}{2}}}{v}$	C^m_m	C^m_D	U	$\frac{C^m_m}{v}$
Line A	1.45	0.617	1.37	0.945	1.75	1.35	(2.75)	1.207
Line B	2.17	0.652	2.28	1.051	2.81	2.32	2.75	1, 295
Line C	1.30	0.692	1.26	0.970	1.55	1.16	1.50	1.192
Line D	1.63	0.583	1.55	0.934	2.10	1.56	2.10	1.288
Line E	(1.61)	(0.608	(1.70)	(1.065)	(2.27)	(1.39)	(1.70)	(1.410)
Line F	1.76	0.603	1.75	0.994	2.27	1.66	2.00	1.290
Line G	(1.16)	(0.570)	(1.13)	(0.974)	(1.85)	(1.45)	(1.75)	(1.595)
Means	1.66	0.624	1.64	0.979	2.10	1.61	2.09	1.254

FLOOD.

Line A	0.62	0.599	0.57	0.919	0.81	0.48	1.20	1.307
Line B	0.77	0.604	0.79	1.026	1.09	0.75	1.05	1.416
Line C	1.03	0.605	1.08	1.049	1.38	0.86	1.05	1.340
Line D	1.08	0.556	1.10	1.019	1.60	1.08	1.40	1.481
Line E	(1.22)	(0.613)	(1.24)	(1.016)	(1.58)	(1.10)	(1.65)	(1.295)
Line F	1.38	0.602	1.42	1.029	1.94	1.40	2.10	1.420
Line G	(1.01)	(0.547)	(1.02)	(1.010)	(1.77)	(1.22)	(1.65)	(1.752)
Means	0.98	0.593	0.99	1.008	1.36	0.91	1.36	1.393

In the means at the foot of these tables lines E and G have not been considered, the first on account of the peculiar circumstances to which its flow is subjected, the latter on account of the great difference between its mean depth and that of the other lines.

The second and the fourth columns in the tables are of interest, as they show relations which are calculated to simplify the work of obtaining volumes of flow. d_m, the depth at which mean velocity is found, varies within small limits, and observations made at 0.624 of the mean ebb depth and 0.593 of the mean flood depth, will doubtless render a very satisfactory approximation to the mean velocity. If it were possible to determine with equal certainty the vertical of the cross-section the V_m of which is equal to v, then the work of gauging would be very much simplified. Unfortunately this has not been found possible from the data at hand. As will be seen from the gauged cross-sections, sheet 15 and 16, the polygon of mean velocities (V_m) in the various parts of the cross-section is generally intersected twice by the line of general mean velocity (v), once on the channel side, near the shore, and once nearer the middle of the river, in a region where the changes in depth are gradual. No definite rule as to the location of these intersections could, however, be deduced beyond this, that for the ebb current the intersection, situated in the region of gradual changes in depth, seems to be at a depth nearly equal to the mean depth of the cross-section for the entire duration of the ebb flow.

A very striking feature of the tables is the equality they establish between the greatest bottom velocity in a cross-section at the time of mamimum current (U_D) and the mean velocity of the cross-section at the same time (C^m_m). The one conspicuous exception to this, line A, ebb, is satisfactorily explained by a note in the field-book, to the effect that on this day, during the strength of the current, it was not possible to get the meter down to the bottom, owing to a lack of suitable weights. C^m_m on its part bears a reasonably constant relation to v, so that for practical use we have

$$(3) \qquad U_D = C^m_m = 1.25\, v.$$

And further

$$(4) \qquad C^m_D = V^m_{\frac{D}{2}} = v.$$

equations, which enable us to determine approximately the important maximum bottom velocities from the easily-found mean velocity. It is, of course, understood that these relations are claimed to exist only locally and, possibly, where the circumstances are the same as on the Lower Savannah River.

8. THE CHANGES PRODUCED BY CROSS-TIDES DAM.

In order to discuss the influence which the construction of the dam has had on the river, a number of cross-sections were platted from line B downward to the lower end of Fig Island, their former forms being obtained from maps of 1874 and 1879, and their present forms being obtained from the map of 1888. For each of these sections area, mean depth, volume of ebb discharge, mean velocity v, and maximum bottom velocity U_D were computed as they were before the construction of the dam and as they are now. Velocity computations were furthermore made for the conditions existing immediately after the completion of the dam before any scour had taken place. This state of affairs is, of course, imaginary, as the dam was built gradually, and the increase of cross-sections proceeded in the same ratio as the growing dam turned greater volumes into Front River. Still, the figures obtained will give a fair measure of the conditions that produced the scour.

Table of comparative data for Front River from line B to lower end of Fig Island.

Cross section.	Before and in 1879.				1889.			
	Volume of ebb flow.	Width.	a a.	Mean depth.	Volume of ebb flow.	Width.	a a.	Mean depth.
	Cubic feet.	*Feet.*	*Sq. ft.*	*Feet.*	*Cubic feet.*	*Feet.*	*Sq. ft.*	*Feet.*
B	405,000,000	810	7,100	8.8	599,000,000	810	9,063	11.2
3	415,314,000	875	7,340	8.6	603,525,544	900	10,415	11.6
4	440,314,640	1,105	9,608	8.7	617,525,544	1,160	11,320	9.8
5	459,014,640	1,550	11,040	7.1	630,725,544	1,615	11,225	7.0
6	474,139,040	1,010	9,281	9.2	641,265,144	1,040	10,650	10.2
7	482,628,440	885	10,141	11.5	644,966,944	940	11,944	12.7
8	492,781,440	560	8,831	15.8	650,695,743	550	10,325	18.8
9	497,436,540	540	8,679	16.1	652,914,444	540	10,388	19.2
10	501,666,140	800	9,720	12.2	655,845,644	800	11,675	14.6
11	510,866,140	900	10,979	11.1	662,605,644	975	13,370	13.8
12	516,326,140	746	10,035	13.5	665,783,644	746	13,086	17.5
13	523,120,540	940	10,734	11.4	669,911,644	900	12,660	14.1
Mean	.....	901	9,457	11.2	.....	915	11,343	13.4

Table of former and present velocities in Front River.

Cross section.	Duration of ebb flow.	1879.		After construction of dam and before cross sections had increased.		1889.	
		$v=C_D^m$	$U_D=C_m^m$	$v=C_D^m$	$U_D=C_m^m$	$v=C_D^m$	$U_D=C_m^m$
	h. m.	*Feet.**	*Feet.**	*Feet.**	*Feet.**	*Feet.**	*Feet.**
B	8 27	1.88	2.35	2.77	3.46	2 17	2.71
3	8 25	1,87	2.34	2.71	3.39	1.91	2.39
4	8 19	1.53	1.91	2.15	2.69	1.82	2.27
5	8 15	1.40	1.75	1.92	2.40	1.89	2.36
6	8 10	1.74	2.17	2.35	2.94	2.05	2.56
7	8 06	1.63	2.04	2.18	2.72	1.85	2.31
8	8 03	1.93	2.41	2.54	3.17	2.17	2.71
9	8 00	1.99	2.49	2.61	3.26	2.18	2.72
10	7 57	1.80	2.25	2.36	2.95	1.96	2.45
11	7 54	1.64	2.05	2.12	2.65	1.74	2.17
12	7 51	1.82	2.27	2.35	2.94	1.80	2.25
13	7 47	1.74	2.17	2.23	2.79	1.89	2.36
Mean	.....	1.75	2.18	2.37	2.96	1.95	2.44

* Per second.

The mean velocities v were easily found by dividing the volume by the product of cross-sectional area and duration of flow, while the maximum bottom velocities U_D were found from these according to equation (3).

We see from the tables that the average mean maximum bottom velocity in Front River through the construction of the dam was raised from 1.75 feet to 2.37 feet per second and that under the scour thus produced, the cross-sectional areas, as well as the

mean depth, have on the average increased about 20 per cent. The increase of the areas has however not been such as to slacken the velocities down to their former values. The flow in Front River to-day, notwithstanding the greater size of the river-bed, is appreciably swifter than it was before the construction of the dam.

It should not be lost sight of that, together with the satisfactory results discussed above, the dam has had the undesirable consequence of reducing the tidal prism of Front River to the extent of probably 75,000,000 cubic feet or more by the heightening of the low-water plane. The great mean ebb velocities in the region of sections 8 and 9 (the river-front of Savannah) might lead one to suppose that a widening of this excessively narrow stretch would result in a less restricted outflow of the ebb and consequently in a partial or entire restoration of the old tidal prism. If, however, the sections 14, 15, 16, and 17 (below Fig Island) are considered it will be seen that there are additional difficulties in that lower region. In the following table are given the present data of the above-named section, concerning which no former data can be given, as the present river-bed there was formed through the construction of the jetty and before such construction existed only as a portion of a larger river-bed.

Hydrographical data of Front River between Fig Island and lower end of jetty.

Cross section.	Volume of ebb flow.	Width.	Area, α_c	Mean depth.	$v = C_D^m$	$U_D = C_m^m$
	Cubic feet.	*Feet.*	*Sq. feet.*	*Feet.*	*Feet.**	*Per second.*
14.....	675, 101, 644	810	10, 944	13. 6	2. 21	2. 76
15.....	677, 796, 644	745	9, 208	12. 4	2. 66	3. 33
16.....	682, 135, 744	1, 000	12, 590	12. 6	1. 97	2. 46
17.....	687, 924, 244	934	14, 335	15. 3	1. 76	2. 20

* Per second.

The velocities at section 15, that is to say, about 3,400 feet below the commencement of Fig Island Jetty, are much greater than at any point above, and an increase of cross-sectional area of Front River for the purpose of increasing its tidal prism would therefore certainly have to commence here. But it seems questionable whether any considerable results could be attained in this way without at the same time involving a loss in mean and in channel depth. Between sections 10 and 12 is situated Garden Bank, over which, according to experience, the river is not able to maintain a dredged channel. The velocity existing here, $v = 1.05$, is therefore less than what is required. There is consequently not much margin for opening up the river above at 8 and 9 without reducing the velocities there dangerously near to that point where they can not maintain their channel depths. In this line of argument there is the element of doubt that a change in the direction of the Garden Bank Cut might tend to make it more permanent. The cut is almost parallel to the Savannah shore, which appears to be the direction of the flood current. By shifting its lower end further away from the Savannah shore the cut would probably be brought into the more favorable direction of the ebb current and then maintain itself.

In view of the peculiar character of the Lower Savannah as a twin river it is exceedingly difficult to arrive at a definite conclusion as to the requirements of widths and cross-sectional area, which difficulty is enhanced by the circumstance that the recent improvements, as far as can be discerned, have not yet resulted anywhere in a state of permanence of the river-bed from which conclusions could be drawn with certainty. The nearest approach to such a state is probably found in the region of sections 8 and 9, and that of sections 21, F, and 22 (see appended Table D). The former points to a mean velocity of somewhat more than 2 feet; the latter, line F, to one of somewhat less than 2 feet. As the latter region has shoaled since 1882, its mean velocity is probably still too small, and we are scarcely far out of the way if we assume a mean velocity of 2 feet as being required for the maintenance of a low-water channel of about 20 feet. The mean depth during ebb outflow, that is, $\frac{a}{\text{width}}$ is hardly less than 18 feet, and assuming these figures we arrive at a cross-sectional area of 11,200 square feet and a width of 620 feet at section 8, and further at a cross-sectional area of 12,600 square feet and a width of from 700 to 750 feet at the lower end of Fig Island Jetty. The present widths, therefore, in nearly all places would have to be restricted by means of jetties or parallel works, and in order to be entirely on the safe side in the execution of this work it should be done gradually. If jetties are decided upon they should be arranged close enough to each other to cause complete shoaling to low water between them.

A region of shoaling that will require annual dredging will probably always remain near the end of Fig Island Jetty, due to the fact that the strong ebb current

coming down Back River and formerly hugging the concave Savannah shore is now shut out from it and can not reach it until somewhat below the end of the jetty. The point, however, where this current now joins the Front River discharge is at the same time the limit below which this shoal can not advance.

9. THE RIVER AT AND BELOW FORT OGLETHORPE.

In the appended Table D cross-sectional areas, depths, and widths are given, as obtained from the survey of 1888–'89 and from surveys made provious to the construction of the wing dams in 1874, 1882, and 1884 at locations shown on the "general sketch," sheet No. 1, and numbered from 1 to 40, the first seventeen of which have been discussed already. The region between the lower end of Fig Island Jetty and the upper end of North Channel is represented in this table by cross-sections 17, 18, 19, 20, and 21, in the areas and depths of which are reflected the peculiar circumstances encountered here.

Immediately below Fig Island Jetty the flow from Back River joins that of Front River, causing a sudden and considerable increase of areas and depths, as shown by sections 18 and 19; below the latter we come to the entrance into South Channel, which drains off a great part of the flow, thereby reducing cross-sectional areas and depths, as shown by section 20; finally we arrive at the head of Spirit Island, where that part of the Back River flow that has not already entered the main stream now joins it on the concave Carolina shore, thus once more increasing cross-sectional areas and depths, as seen in section 21, F, and 22. This region of rapid and repeated changes could hardly be permanently regulated in any other way than by closing the upper entrance into South Channel, a proceeding, however, that, apart from the needs of inland navigation, can not be recommended for other weighty reasons.

In the first place, it is probable that the tidal status of the river would be unfavorably affected by it, and in the second place, heavy freshets being wholly thrown on the North Channel might cause serious damage to the works of improvement there.

In North Channel, below the upper end of Spirit Island, the water has been improved through restriction of the widths by means of a number of wing-dams. In regard to the widths given to the openings a criterion is offered by the state of affairs near the upper end of North Channel. The mean circumstances here are represented by the following figures, deduced from sections 21, F, and 22:

	1888.	1882.
Width ..... feet..	1,307	1,290
Cross-sectional area, a_c ..... square feet..	25,425	27,337
Mean depth, $\frac{a_c}{\text{width}}$ ..... feet..	10.4	21.4
Channel depth ..... do...	30.8	34

Under the influence of the closing of Back River immediately above, areas and depths have decreased since 1882, but may be supposed to have arrived somewhere near a state of permanence by this time. If we assume as above a required mean velocity of $v = 2$ feet, then this and the known discharge and duration of ebb flow at F (1,086 million cubic feet and $7^h\ 07^m$) lead us to a cross-sectional area of 21,200 square feet. From the figures of 1888 and 1882 as rendered above, and from further evidence furnished by Table D in regard to the channel depths corresponding to mean depths of 18 feet and more, it appears pretty certain that this mean depth is sufficient for the contemplated channel improvement, which conclusion would lead us to a required width of about 1,200 feet.

At the Long Island crossing, say between wing-dams 33 and 35, we have an ebb discharge of 1,693,000,000 cubic feet. Assuming a duration of ebb flow of seven hours and the same mean velocity and mean depths as before, this leads us to a cross-section of about 33,600 square feet and a width of 1,870 feet. According to this line of argument, therefore, a gradual increase of widths from about 1,200 feet at the upper end of Spirit Island to about 1,870 feet on Long Island Crossing would meet the requirements of the contemplated improvement. In point of fact, the widths, especially in the lower part, have been restricted considerably more, so that the available evidence convincingly points to the fact of the plan of improvement having, to say the least, gone far enough in this direction. The results obtained are in a measure represented

by the following figures, which are the means of sections 22 to 40, that is to say the entire length of the improved North Channel:

	1888.	1882–1884.
Average cross-sectional area, a_e ..... square feet..	32, 810	38, 530
Average mean depth, $\frac{a_e}{\text{width}}$ ..... feet..	13. 8	12. 7
Average channel depth ..... do...	20. 2	17 5

In the light of the foregoing these figures seem somewhat disappointing; one might have been inclined to expect more, especially in regard to depths. But it should be remembered that they represent the mean conditions of a stretch of river about 5½ miles in length in which the required improvement works have as yet only partially been carried out. In the immediate vicinity of the present works the depths have increased considerably, as will be seen by reference to table D; but these works are too far apart to make their influence felt all over the intervening spaces.

Before leaving the subject of North Channel it should be mentioned that in order to secure permanence between wing-dams 4–23 and 6–25 it will probably become necessary to close the channel between Spirit and Elba islands at its lower end.

10. TYBEE KNOLL.

On the Knoll dredging does not at present render any permanent results, presumably because the current is not strong enough to maintain them, and the construction of a second training-wall parallel to the existing one is contemplated, in order to more effectually concentrate the flow. The question arises whether this would not result, as in other similar cases, in a seaward movement of the bar instead of its destruction and whether it would not be preferable to increase the flow instead of restricting it, which former can be done by utilizing a part of the volume now moving in South Channel.

If an opening of suitable size is excavated between Cockspur Island and Long Island as indicated on general sketch, sheet No. 1, and the lower end of South Channel is gradually closed by a dam, which is built up slowly, then the South Channel flow will be more and more diverted into such opening and thence over the Knoll, in the same measure as the growing dam more and more obstructs its exit through the present mouth of South Channel. The gradual execution of the plan would be an important element of perfect safety as far as the conservation of the tidal status of the river is concerned; if at any stage of the closing of South Channel, a decrease of the tidal prism should become apparent (which is not anticipated), then the timely stoppage of the work would prevent it from assuming serious proportions. The circumstances to be considered in reference to this plan are as follows:

The ebb volume of North Channel at Oyster Bed was found at 2,033,000,000 cubic feet, in which the unknown flow from Wright's River is not included. The cross-sectional area at the Knoll may be put at about 40,000 square feet and the duration of ebb flow at about seven hours. If the entire above volume is assumed to pass over the Knoll, then this renders a mean velocity of about $v = 2$ feet per second, that is to say, about the same at which according to the evidence available Front River and North Channel, which are not exposed to the direct action of ocean waves, will maintain a deep channel. But on the Knoll the waves of any heavy and protracted northeasterly gale will stir up and set in motion enormous quantities of material, which the ebb flow, weakened during the continuance of the gale, is not able to prevent from settling in the deep places. This process repeating itself during the stormy season of the year, is apt to result in filling any cuts that may have been made.

Now, if 500,000,000 cubic feet were diverted from South Channel over the Knoll in the above-described way, then the mean velocity on the latter would be increased from 2 feet to 2.5 feet per second, representing a mean bottom velocity at the time of maximum current of 2.5 feet and a channel bottom velocity at the same time of more than 3 feet per second, which would probably prove sufficient for the object in view. The possibility of diverting the above amount over the Knoll can not be doubted, when it is considered that South Channel at present has an ebb discharge (at Lazeretto Creek) of 868,000,000 cubic feet, which is the limit of supply only, if the needs of inland navigation are deemed of sufficient importance to imperatively forbid the closing of St. Augustine Creek. If this latter operation were admissible, then the discharge of South Charnel could thereby be increased to more than 1,100,000,000 cubic feet, of which 200,000,000 or 300,000,000 more could be diverted over the Knoll.

11. BORINGS ON TYBEE KNOLL.

According to your instructions borings were taken at Tybee Knoll at the following places:

1. Near Buoy No. 9, in a mean low-water depth of 16.5 feet.

2. Near Buoy No. 7, in a mean low-water depth of 16.8 feet.
3. Close to and south of training-wall running easterly from Oyster Bed Shoal, about half way between buoys No. 7 and 9, in a mean low-water depth of 21.8 feet.

A boring was attempted on that part of the "ridge" south of buoy No. 9, which runs dry at low water, but it was found impossible with the appliances at hand to penetrate the exceedingly hard and apparently thick coat of oyster shells that covered the bank like a firm and close pavement.

At No. 1 no boring core and consequently no samples were obtained; a hard layer of apparently sand was reached at 26 feet below mean low-water. Above this there was soft mud covered by a harder layer of about 2 feet thickness at the top.

At No. 2 the soft mud, without any hard covering, extended to a depth of 31 feet below mean low water, when clay was found, and at 32 feet a mixture of sand and clay was struck, which became very hard at 34.5 feet.

At No. 3 soft mud with sand extended to a depth of 26 feet below mean low water, when clay was found; at 32 feet a hard mixture of sand and clay was found.

A number of samples taken from the bore-holes are submitted herewith, as is also a sketch showing diagrammatically the results of boring.

The following is a list of the appendices to this report:

1. Tables marked A. Observed duration and length of flow. Fourteen individual tables.
2. Tables marked B. Volumes of flow and mean velocities (V^m) as corrected to mean tidal conditions. Fourteen individual tables.
3. Tables marked C (in text of report). Tables of velocities and the relations between them. Fourteen individual tables.
4. Table marked D. Comparative data for the lower Savannah River.
5. Diagram of borings.
6. Index.

Submitting the above, I am, Lieutenant,

Very respectfully, your obedient servant,

E. A. GIESELER,
Assistant Engineer.

Lieut. O. M. CARTER,
Corps of Engineers, U. S. A.

SUPPLEMENTARY REPORT ON SURVEY OF SAVANNAH RIVER FROM CROSS TIDES TO THE SEA.

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SUPPLEMENTARY REPORT OF MR. E. A. GIESELER, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., June 9, 1890.

SIR: I have the honor to report as follows upon additional work done in connection with the survey of Savannah River. This work was done in accordance with the following instructions issued by you:

"Careful soundings will be taken in the Savannah River from Cross Tides to Tybee Roads. If possible, a few soundings will also be taken in the South Channel and in the Back River as far up as Screven's Ferry.

"Surface, mid-depth, and bottom directions and velocities of ebb and flood currents on Tybee Knoll.

"Volume of flood flow and of ebb discharge passing to the north of Oyster Bed.

"Amount and character of sediment at various depths transported both on the ebb and flood tide.

"Direction of sand and silt movement on shoals to the north and east of the Oyster Bed.

"Character of river bottom on Tybee Knoll to a depth of 22 feet at mean low water."

The sounding work was placed in charge of Mr. A. S. Cooper, and executed between April 4 and May 14. The platting and entering of these soundings on the new sheets prepared for them are still under way at the time this is written, and are likewise under the immediate charge of Mr. Cooper.

The instructions as to velocities and directions to be observed on Tybee Knoll were given with the intention that the Haskell-Ritchie current-meter should be used in carrying out the work. It was found, however, that this instrument was not in the required perfect order, and as time pressed you decided to introduce float observations of direction, in the place of the more complete ones originally intended. These, as well as the observations for velocity on Tybee Knoll, have been made, but only for the ebb tide, rough weather setting in on their completion, and effectually preventing any further work in this exceedingly exposed locality.

In order to find the volume of the ebb and flood flow north of Oyster Bed Shoal, two methods presented themselves, viz:

1. A direct method, by gauging the cross-sections in question.

2. An indirect method, by gauging the volume of North Channel and Wright's River and the volumes passing between Fort Pulaski and Oyster Bed Shoal. The difference between the latter and the sum of the two former must be the volume sought.

It was decided to employ this indirect method, because from it good results could be expected without time-robbing observations of direction, which the direct method undoubtedly would have necessitated. At the same time the indirect method had the advantage of being a check on last year's gauging and of rendering information upon the important flow over Tybee Knoll.

The following three cross-sections were accordingly selected for gauging:

Line H on Long Island Crossing, at the locality of the old line L–K, of the survey of 1879.

Line I, between Oyster Bed Shoal and Cockspur Island.

Line K, in Wright's River, about half a mile upward from its mouth.

The exact location of these lines is shown on sheet No. 25 accompanying this report, while the cross-sections themselves, as found from careful soundings, are rendered on sheet No. 26.

On account of pressure of time it was decided to work simultaneously with the entire number of meters available, viz, three Stackpole propeller meters and two Ellis meters, and to complete each cross-section in one successful day by simultaneous observations on five verticals in the case of lines H and I, and on three verticals in the case of line K. This simultaneousness of observations on an entire cross-section had the disadvantage of a necessarily small number of points of observations (verticals), but, on the other hand, it had the undoubted advantage of rendering a result subject throughout to uniform conditions of tide and of fresh-water flow.

All meters having recently undergone repairs had to be rerated, which work was executed by the writer with the following results:

Propeller meter I:	$a=1.81$,	$b=0.04$
Propeller meter II:	$a=1.88$,	$b=0.09$
Propeller meter III:	$a=1.67$,	$b=0.05$
Ellis meter A:	$a=3.50$,	$b=0.07$
Ellis meter B:	$a=3.50$,	$b=0.00$

Three Leclanche and two electropoion batteries of two cells each and a reserve of two Grenet batteries were prepared. Five flat-bottomed boats were rigged for obser-

vations in the same way as during last year's work, and the necessary spring planks, standing lines and weights for same, chains, meter sinkers, anchors, lines, etc., were provided for each, everything being sent down to the old "Engineer House" on Oyster Bed Shoal, where the corps of observers and the men were quartered. Careful soundings were taken on the lines selected and according to them the points of observation were determined upon and marked by buoys. All these preparations were completed on the night of May 15, and on the early morning of May 16 each of the five boats took its position at the buoy allotted to it on line H, and gauging was commenced with the following gentlemen observing, besides the writer: First Lieut. Thomas H. Rees, Corps of Engineers, U. S. Army; Mr. A. S. Cooper, Mr. George W. Brown, and Mr. W. A. Dayton.

On the 16th, the 17th, and forenoon of the 18th work was favored by such smooth water as is rarely found in that exposed locality, and it was therefore possible during this time to finish that portion, which was at once the most important and the most difficult one, viz, the lines H, I, and the ebb observations on Tybee Knoll, while the less important and comparatively sheltered line K was gauged on the 19th in somewhat windy weather.

The method of working was the same as that followed last year and described in my report of January 31, 1890, and from the 16th to the 20th of May there were taken, according to it, about 4,500 single observations at 14 different points or verticals. On all the three lines a practically complete ebb and flood tide was obtained, with this exception, that on line I the greater part of the ebb was lost on two verticals, through the breaking down of the Ellis meters. The observations on the other three verticals, however, being complete it was practicable to supply the missing data by means of interpolation, sufficiently exact for the purpose in view. I desire to mention here that the Stackpole propeller meter has again on this occasion proved itself a most reliable instrument for observations in strong salt-water currents and exposed localities.

1. EBB AND FLOOD VOLUMES.

The methods of computation were the same as those employed previously and described in my report of January 31, 1890. Fourteen sheets of velocity diagrams and three sheets of tidal diagrams, in which are embodied the entire field results, are submitted herewith. In regard to the tidal observations it should be mentioned that staff gauges were put at lines H and K and observed in the usual way during the gauging of these lines, while line I was referred to the self-registering gauge at Fort Pulaski. The latter, which was running constantly during the entire time of work, was also utilized to determine mean conditions at the other places.

The results of computations are rendered in two appended tables, entitled:

Table E. Observed duration and length of flow.

Table F. Volume of flow and mean velocities as corrected to mean tidal conditions.

The ebb and flood volumes as obtained at each cross-section and corrected to tide are as follows:

Line.	Ebb volume.	Flood volume.
	Cubic feet.	*Cubic feet.*
H	1,629,777,114	1,410,658,180
I	1,392,081,839	1,048,610,121
K	288,000,857	321,429,730

From the records of the gauge at Augusta it was found that the conditions of fresh-water flow existing at the time the various lines were gauged, were as follows:

Line.	Reading of gauge at Augusta.	Consequently as compared with mean fresh-water flow. Deficiency in cubic feet per second.
H	8.5	2,900
I	7.5	4,500
Tybee Knoll	7.2	4,900
K	7.2	4,900

It will be seen from this table that the volume of fresh-water flow was below the mean during the entire duration of gauging operations; the ebb volumes were therefore found too small and the flood volumes too great, and both have to be corrected

accordingly. From a careful consideration of the relative size of the various channels and their volumes of flow, the percentage of the full deficiency of fresh-water flow to be applied in each case was estimated as follows:

Line H: Four-sevenths of deficiency to be applied.
Line I: One-half of deficiency to be applied.
Tybee Knoll: One-half of deficiency to be applied.
Line K: One-tenth of deficiency to be applied.

These figures, in connection with the mean duration of flow on date of observation, render the following corrections to be applied to the volume as found above.

Line.	Ebb correction.	Flood correction.
	Cubic feet.	*Cubic feet.*
H	+39, 840, 000	—34, 461, 600
I	+52, 785, 000	—45, 360, 000
K	+10, 495, 800	—10, 907, 400

Applying these corrections we now obtain the *true volumes of ebb and flood flow*, corrected to mean conditions of tide and of fresh-water flow, as follows:

Line.	True ebb volume.	True flood volume.
	Cubic feet.	*Cubic feet.*
H	1, 669, 617, 114	1, 376, 196, 580
I	1, 444, 866, 839	1, 003, 250, 121
K	298, 496, 657	310, 522, 330

The anomaly of a greater flood inflow than ebb discharge on line K may possibly be explained by the flow through Wall's Cut, which on the ebb tide is said to be stronger than on the flood tide. But the discrepancy is not sufficiently great to exclude with certainty the possibility of it having been caused by errors incident on the great distance between verticals and, possibly, on the rough weather on the day of observations.

The first check on the above results that offers itself is the test of the difference between ebb and flood volume at line H. If it were not for the flow through the "Gaps" this difference ought to be practically the same as the difference between the same volumes at line F and G, which is as follows, according to the figures of the report of January 31: 1,163,323,898—791-751,518=383,472,380. The flow through the "Gaps" has been estimated as follow in the same report:

	Cubic feet.
Flood outflow into South Channel	160, 000, 000
Ebb inflow from South Channel	60, 000, 000

If these figures are correct, then the flow through the "Gaps" increases the flood flow of North Channel below by 100,000,000 cubic feet more than it increases the ebb flow, and the difference between the two must therefore be by that much smaller than it is above the "Gaps;" that is, it should be about 280,000,000 cubic feet. As a matter of fact our results give it quite near to this figure; that is, at about 293,000,000 cubic feet.

A more reliable test than this is afforded by comparison with the tidal prism and the volumes at lines F and G. Line H, as mentioned before, is identical with the old line L K, the ebb volume for which is given in the January report (under heading "The river at and below Fort Oglethorpe") at 1,693,000,000 cubic feet. This agrees almost exactly with the figures found now, the difference only amounting to 1½ per cent. But the figures found at that time for P and for $e+f$ were based on suppositions in regard to the time of slack water below that have not been entirely verified by the present work. and by the aid of the information obtained now we derive the volume of flow at line H as follows:

Ebb:	Cubic feet.
Total of ebb outflow at lines F and G	1, 163, 323, 898
Estimated flow through the "Gaps"	60, 000, 000
Tidal prism between lines F, G, and H	542, 600, 000
	1, 765, 923, 988
Less $e+f$ at line F	50, 000, 000
Ebb outflow at line H	1, 715, 923, 898

Flood:	Cubic feet.
Total of flood inflow at lines F and G	769,851,518
Estimated flow through the "Gaps"	160,000,000
Tidal prism between lines F, G, and H	542,600,000
	1,472,451,518
Less $e + f$ at line F	50,000,000
Flood inflow at line H	1,422,451,518

If these volumes are compared with the ones found by the present ganging and given above, it will be seen that there is a difference of about $2\frac{3}{8}$ per cent. in the ebb flow and of one about $3\frac{1}{2}$ per cent. in the flood flow, the difference in both cases being in the same direction. This result is certainly as close as could be expected, and the verification it renders of last year's as well as of this year's work must be pronounced satisfactory.

Having thus tested our results, we now find the flow north of Oyster Bed Shoal as follows:

The flow north of Oyster Bed Shoal.

Ebb:	Cubic feet.
Ebb volume, line H	1,669,617,114
Ebb volume, line K	298,496,657
Tidal prism between H, K, and I	411,960,000
	2,380,073,771
Less ebb volume, at line I.	1,444,866,839
Ebb volume passing north of Oyster Bed	935,206,932
Flood:	
Flood volume, line H	1,376,196,580
Flood volume, line K	310,522,330
Tidal prism	411,960,000
	2,098,678,910
Less flood volume, line I	1,003,250,121
Flood volume passing north of Oyster Bed	1,095,428,789

2. DEDUCTIONS.

In discussing the improvement of Tybee Knoll in the report of January 31, it was assumed that the entire flow of North Channel passes between Cockspur Island and Oyster Bed and thence over the "Knoll," while the only flow north of Oyster Bed was supposed to consist of the Wright's River volume. On this basis the mean ebb velocity on the "Knoll" was computed at 2 feet per second and reasons were given why this velocity, which appears to be sufficient further above, is probably insufficient here to keep the channel open.

We now find that the supposition made in the former report is erroneous, a very considerable portion of the ebb as well as of the flood flow of North Channel passing north of Oyster Bed Shoal. Of the former only about 1,445,000,000 cubic feet pass south of it and if we add to this a prism of about 155,000,000 cubic feet, we have the ebb volume at a point on the "Knoll" about half a mile above the lower end of Oyster Bed Training-wall, which is the point where the observations for velocity and direction were taken on May 19, and which is designated as such on sheet No. 25. Assuming as before a cross-sectional area of 40,000 square feet and a mean duration of ebb flow of $6^h\ 35^m$ we now arrive at a mean velocity of

$$v = 1.68$$

That is to say, considerably less than was assumed in the January report and also less than the river appears to require above to hold its own. This mean velocity, according to the relations found in the previous report, would indicate a bottom velocity in the channel at the time of maximum current of

$$U_D = 1.68 + 1.25 = 2.10$$

But this value as actually found by observations during maximum ebb current (see diagram on sheet No. 25) is still less, viz:

$$U_D = 180.$$

It should be stated here that this discrepancy probably arises from having assumed too small a proportion of the cross-section over Tybee Knoll as pertaining to North Channel in computing the first value of U_D.

It appears manifest from all this that the maximum scouring velocities on Tybee Knoll are even weaker than those existing at present in the river above and all the arguments that were advanced in the former report towards increasing the flow over the "Knoll" have therefore gained in weight through our present results. But in the light of our present information there appear to be other ways of doing this besides the one outlined in the previous report.

The considerable flow to the north of Oyster Bed in a great measure must be ascribed to the contraction of the river-bed between this place and Cockspur Island, where the cross-sectional area of mean ebb outflow (at line I) is reduced to about 35,000 square feet (that is, about the same size as the northern opening). Without the existence of this gorge it is safe to say that a much greater volume, following the natural tendency of the flow to hug the concave shore, would pass south of Oyster Bed, and there can hardly be any doubt that the effectual opening of this passage by an increase of cross-sectional areas, say to 40,000 square feet, will be followed by an increased flow through it and consequently over the "Knoll." This would all the more appear as the necessary initiatory step of work of creating a greater flow at the latter place, as the directing of additional volumes into the gorge as existing at present would increase the currents in the narrow channel to an extent that might become dangerous to navigation

After the completion of this work and when the new relation of volumes north and south of Oyster Bed has been ascertained by actual measurement, then the question will have to be approached, What further steps should be taken toward still more increasing the flow on Tybee Knoll? If there is still a considerable volume escaping through the northern opening, then, besides the plan outlined in the report of January 31, the closing of each opening can be resorted to, either by continuing the present jetty or by building a training-wall from Oyster Bed Shoal to the lower end of Jones's Island, the first having the advantage of utilizing the volume of Wright's River, the latter apparently more effectually considering the improvement of the river stretch immediately above Oyster Bed.

Whether the flow of South Channel is utilized or whether the opening north of Oyster Bed is closed, the important question that arises in reference to either plan will be whether its execution would diminish the tidal flow of the river, a consequence which, of course, must be avoided. A definite answer to this question can be given by actual experience only, which can be gained in an entirely safe way by a gradual and cautious construction of the works of improvement, while at the same time continuous observations of high and low water are made at Long Island Crossing, at Fort Oglethorpe, and possibly a point still further up, and at Fort Pulaski. If to these is added the information accessible from the U. S. Coast Survey tide-gauge at Tybee Island, then it appears certain that the least shrinkage in tidal range would instantly become apparent in the differences, especially of the low-water observations, above and below. Such shrinkage could then be verified by the gauging of the river at line H and at the mouth of South Channel, and under the continuous and cautious guidance of these observations it would appear to be quite safe to slowly advance the construction of the works of improvement decided upon until either the desired amount of flow has been diverted over the "Knoll" or until a timely halt has been called by observed changes in the tidal range.

In conclusion I beg to say that of the work enumerated in your instructions there remains to be done the investigations in regard to amount and character of sediment transported on ebb and on flood tide and the observations of the direction of the movement of sand and silt on the shoals north and east of Oyster Bed, the execution of which had to be postponed on account of lack of time.

It should be mentioned here that the self-registering tide-gauges at Fort Pulaski and at Fort Oglethorpe have been continued uninterruptedly, and that since the commencement of April, 1890, a third self-registering tide-gauge has been established at Parrysburg. I would recommend to continue all these, at least until the occurrence of a high freshet in the upper river, so as to establish with certainty the propagation of the same and the extent and magnitude of its influence in the lower river.

The following is a list of appendices to this report:


1. Tables marked E.—Observed duration and length of flow on lines H, I, and K.
2. Tables marked F.—Volumes of flow and mean velocities as corrected to mean tidal conditions.
3. Index.

Submitting the above, I am, Lieutenant,

Very respectfully, your obedient servant,

E. A. GIESELER,
Assistant Engineer.

Lieut. O. M. CARTER,
Corps of Engineers, U. S. A.


SHEET No 1.
HYDROGRAPHICAL SURVEY
OF
SAVANNAH RIVER, GEORGIA
Made 1889 under the direction of
O.M. CARTER, 1ST LT. CORPS OF ENGRS., U.S.A.
By
E. A. Gieseler, Assistant Engineer.
(GENERAL SKETCH SHOWING LOCATION OF TIDE GAUGES AND OF GAUGED CROSS SECTIONS)
Scale of Feet
1000 0 1000 2000 3000 4000
SOUTH CAROLINA
GEORGIA
ATLANTIC OCEAN
ARGYLE ISLAND
Onslow Island
RECESS GAUGE
CROSS TIDES GAUGE (LOWER)
CROSS TIDES GAUGE (UPPER)
HUTCHINSONS ISLAND
BACK RIVER
Pennyworth Isld.
READ'S MILL GAUGE
Marsh I.
FRONT RIVER
CENTRAL R.R. WHARF GAUGE
SAVANNAH
BARGE OFFICE GAUGE
S.F.& W. R.R. WHARF GAUGE
Fig Island
FT. OGLETHORPE GAUGE
Ft. Oglethorpe
Barnwell Island
No. 2
No. 3
OBSTRUCTIONS GAUGE
Spirit Island
SPIRIT ISLAND GAUGE
ELBA ISLAND
NORTH CHANNEL
LOWER ELBA ISLAND GAUGE
ST. AUGUSTINE CRK. GAUGE
SOUTH CHANNEL
Bird Island
VENUS POINT GAUGE
JONES ISLAND
WRIGHT'S RIVER
TURTLE ISLAND
LONG ISLAND
Oyster Bed
PROPOSED CUT
Ft. Pulaski
FT. PULASKI GAUGE
COCKSPUR I.
LAZARETTO CRK.
TYBEE ISLAND
TYBEE ISLAND GAUGE
With Report on Survey of Savannah River made 1889.

Eng 90

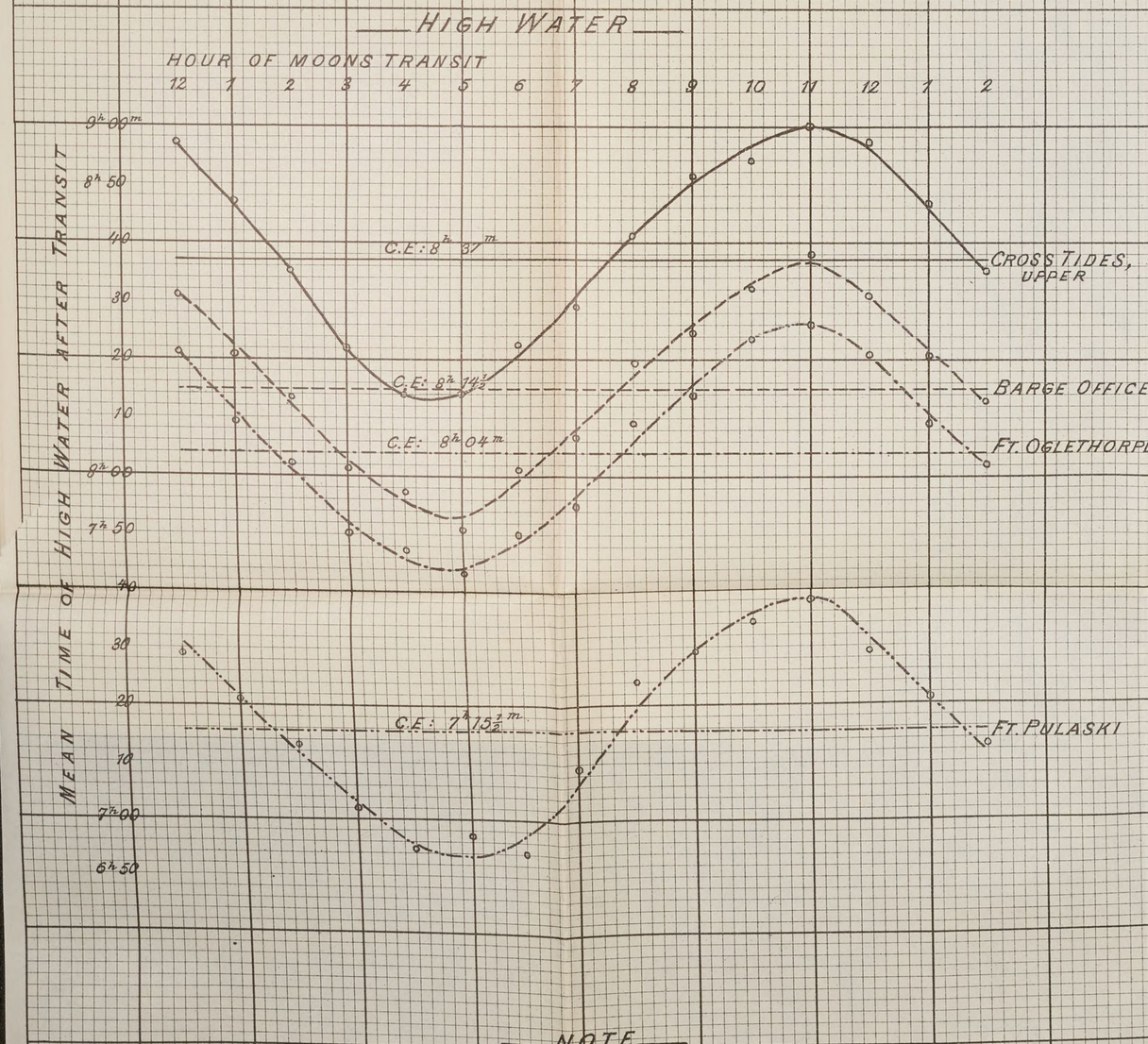
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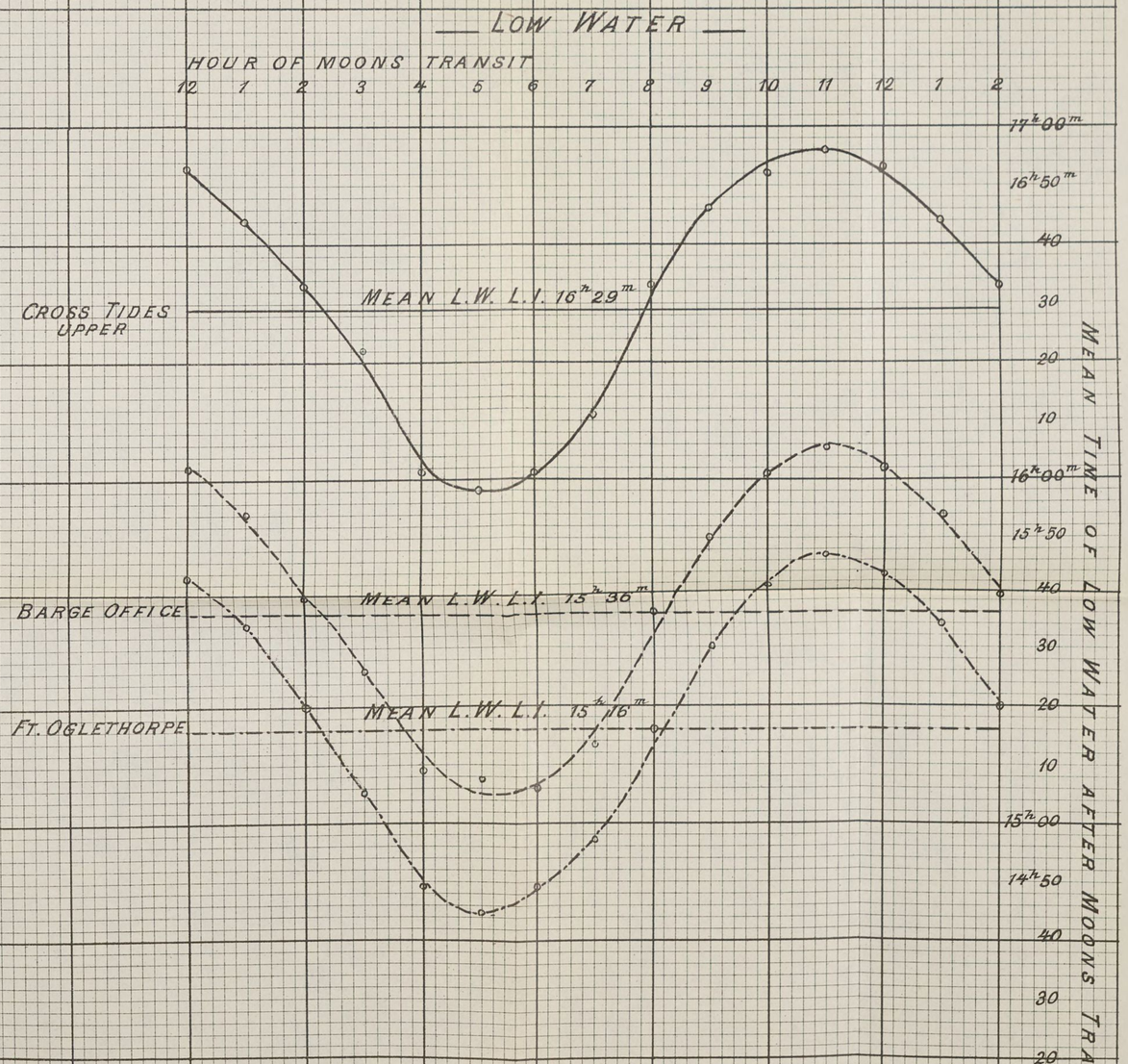
THE SEMIMENSTRUAL INEQUALITY OF THE TIME OF HIGH AND LOW WATER ON THE LOWER SAVANNAH RIVER

COMPILED UNDER THE DIRECTION OF

O. M. CARTER, 1ST. LT. CORPS OF ENGRS. U.S.A.

BY E. A. GIESELER, ASST. ENGR.





NOTE

THE POINTS MARKED BY SMALL CIRCLES INDICATE THE LUNITIDAL INTERVALS DERIVED FROM THE MEANS OF ACTUAL OBSERVATIONS MADE FROM APRIL TO AUGUST 1889.

THE NUMBER OF OBSERVATIONS MADE WAS AS FOLLOWS:

CROSS TIDES:	267 HIGH &	247 LOW WATERS
BARGE OFFICE:	252 HIGH &	250 LOW WATERS
FT. OGLETHORPE:	255 HIGH &	257 LOW WATERS
FT. PULASKI:	230 HIGH &	230 LOW WATERS

THE DIAGRAMS CORRESPOND TO MEAN CONDITIONS OF LUNAR PARALLAX AND DECLINATION. FOR A DIFFERENCE OF 10° IN LUNAR DECLINATION THERE ARE THE FOLLOWING DIFFERENCES IN THE TIME OF LOW WATER:

FT. PULASKI	6 MIN.	BARGE OFFICE	6.2 MIN.
FT. OGLETHORPE	6 "	CROSS TIDES	8 "

WITH REPORT ON SURVEY OF SAVANNAH RIVER, MADE 1889 BY E. A. GIESELER, ASST. ENGR.

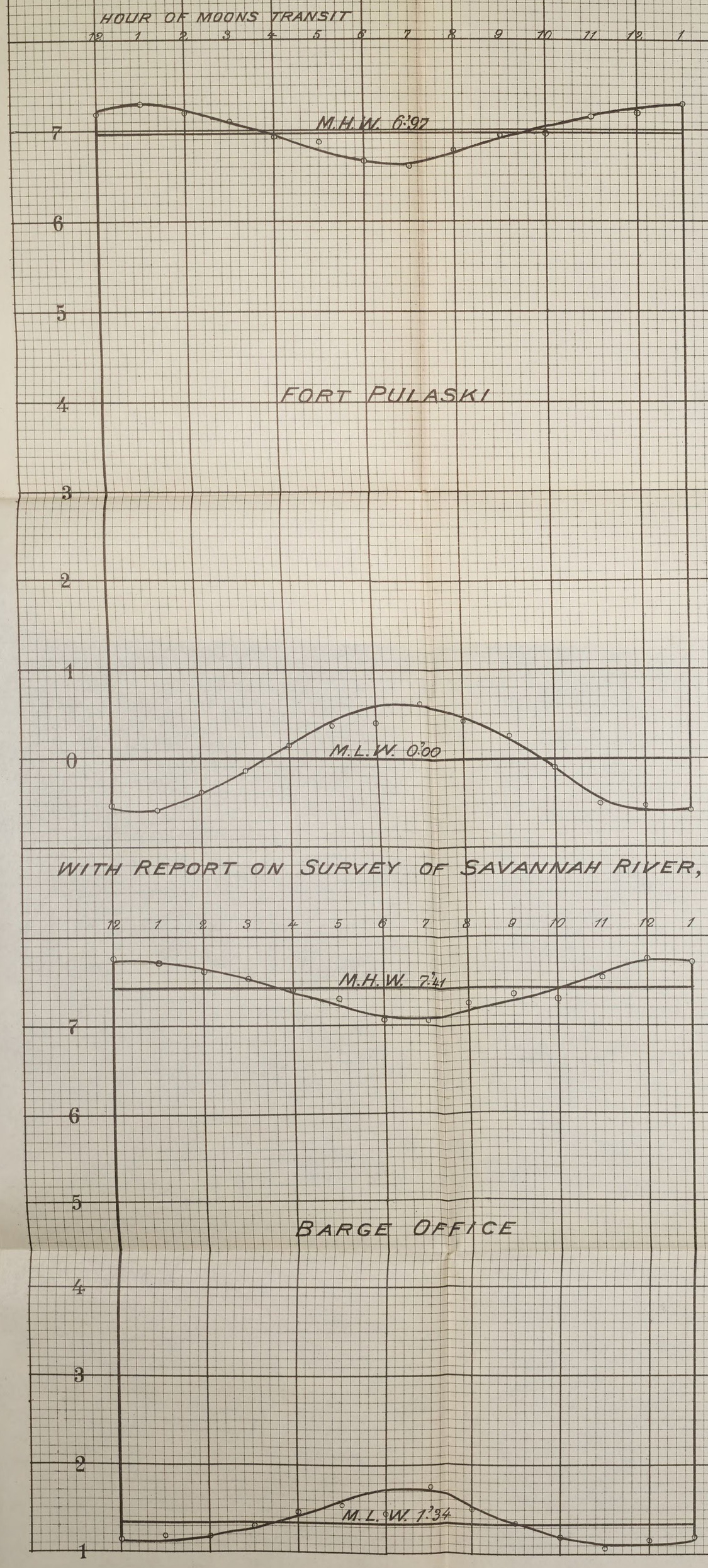
SHEET No 3

THE SEMIMENSTRUAL INEQUALITY OF THE HEIGHT OF HIGH AND LOW WATER ON THE LOWER SAVANNAH RIVER

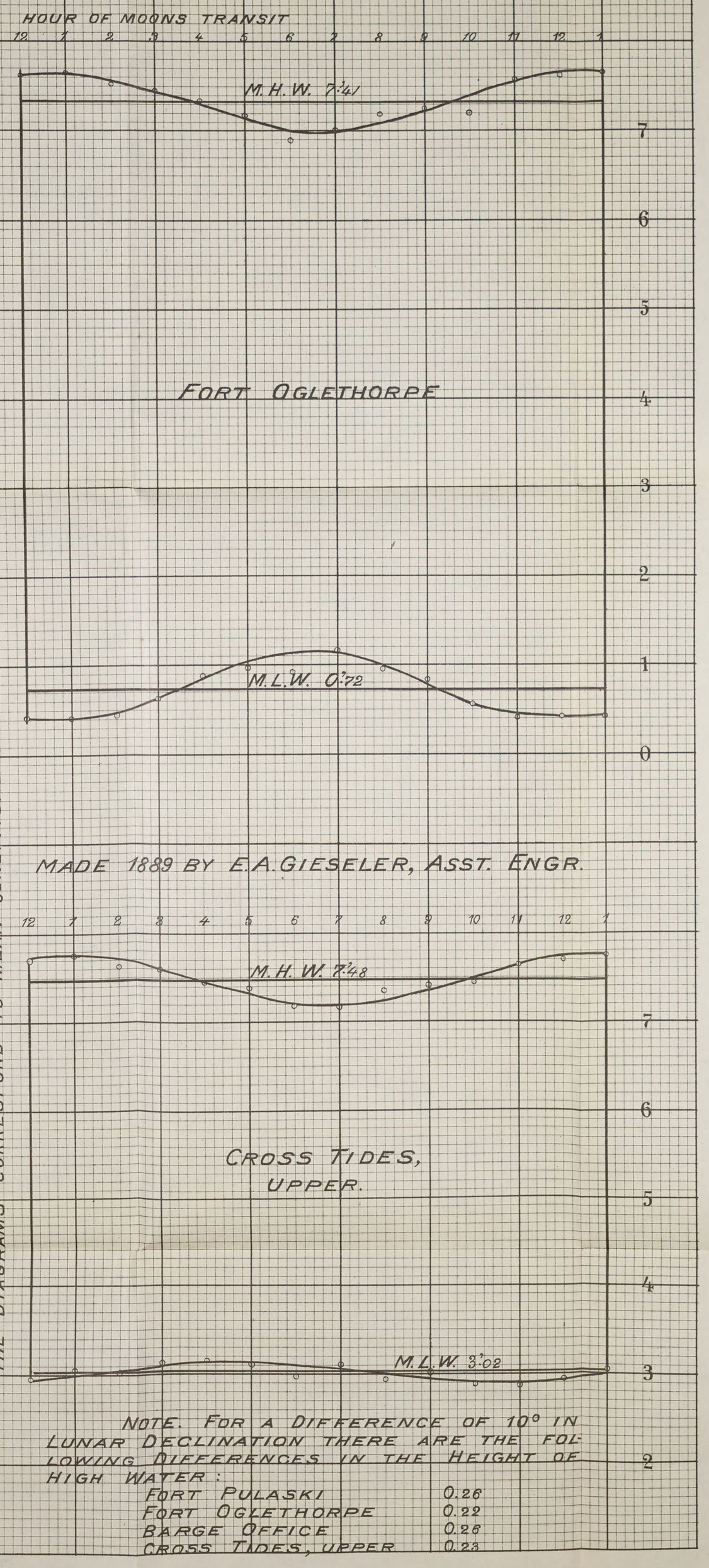
COMPILED UNDER THE DIRECTION OF

O. M. CARTER, 1ST LT. CORPS OF ENGRS. U.S.A.

BY E.A. GIESELER, ASST. ENGR.



FORT PULASKI



FORT OGLETHORPE

WITH REPORT ON SURVEY OF SAVANNAH RIVER, MADE 1889 BY E.A. GIESELER, ASST. ENGR.

BARGE OFFICE

NOTE. ALL HEIGHTS ARE REFERRED TO THE PLANE OF MEAN LOW WATER AT FORT PULASKI.
THE DIAGRAMS CORRESPOND TO MEAN CONDITIONS OF LUNAR PARALLAX AND DECLINATION.

CROSS TIDES, UPPER.

NOTE. FOR A DIFFERENCE OF 10° IN LUNAR DECLINATION THERE ARE THE FOLLOWING DIFFERENCES IN THE HEIGHT OF HIGH WATER:

FORT PULASKI	0.26
FORT OGLETHORPE	0.22
BARGE OFFICE	0.26
CROSS TIDES, UPPER	0.23

SHEET No4

HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER GA.

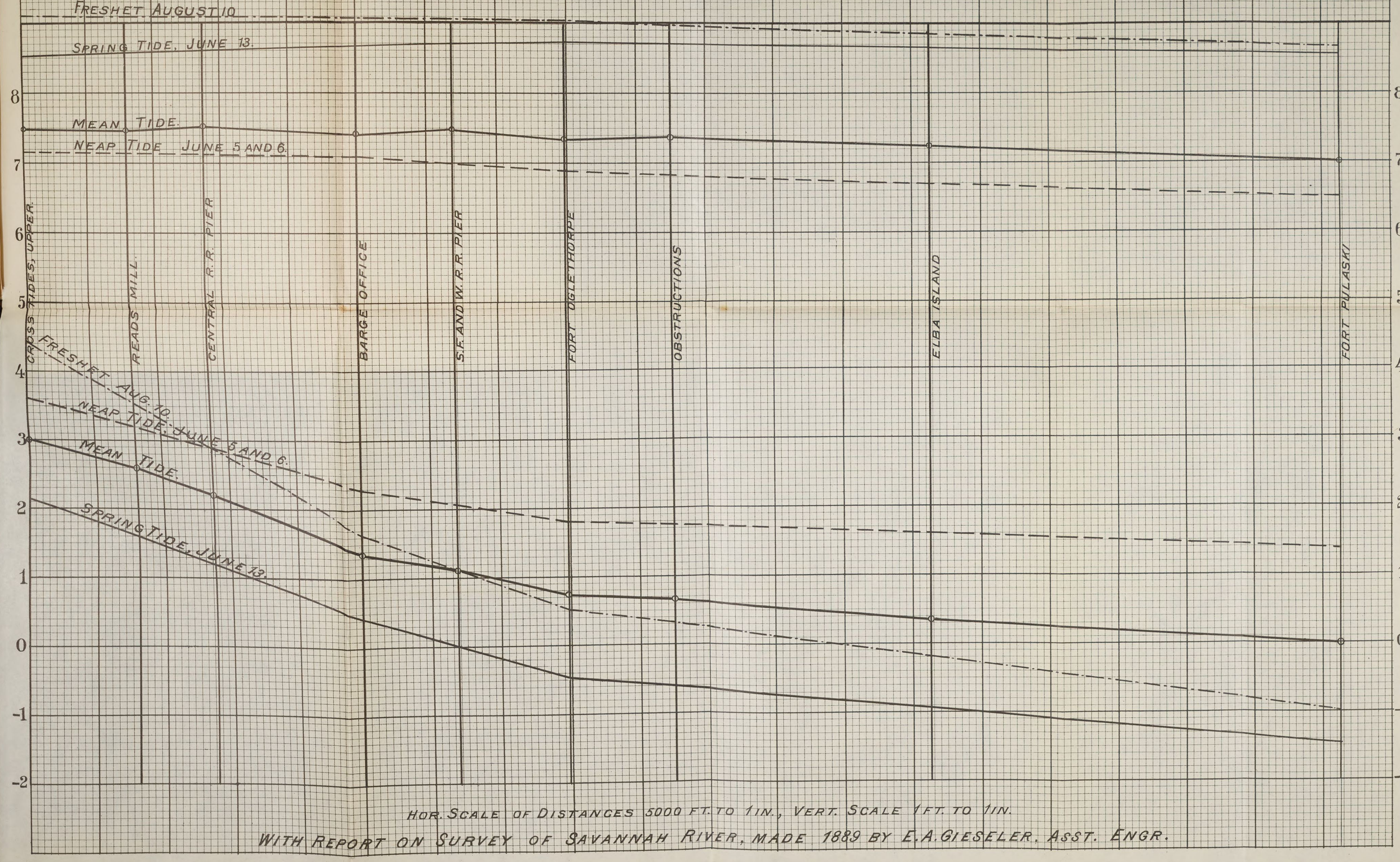
MADE UNDER THE DIRECTION OF

O.M. CARTER, 1ST LT. CORPS OF ENGRS. U.S.A.

LINES OF HIGH AND LOW WATER

FRONT RIVER AND NORTH CHANNEL

ALL HEIGHTS ARE REDUCED TO MEAN LOW WATER AT FORT PULASKI



HOR. SCALE OF DISTANCES 5000 FT. TO 1 IN., VERT. SCALE 1 FT. TO 1 IN.

WITH REPORT ON SURVEY OF SAVANNAH RIVER, MADE 1889 BY E.A. GIESELER, ASST. ENGR.

SHEET No. 5.

HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER GA.

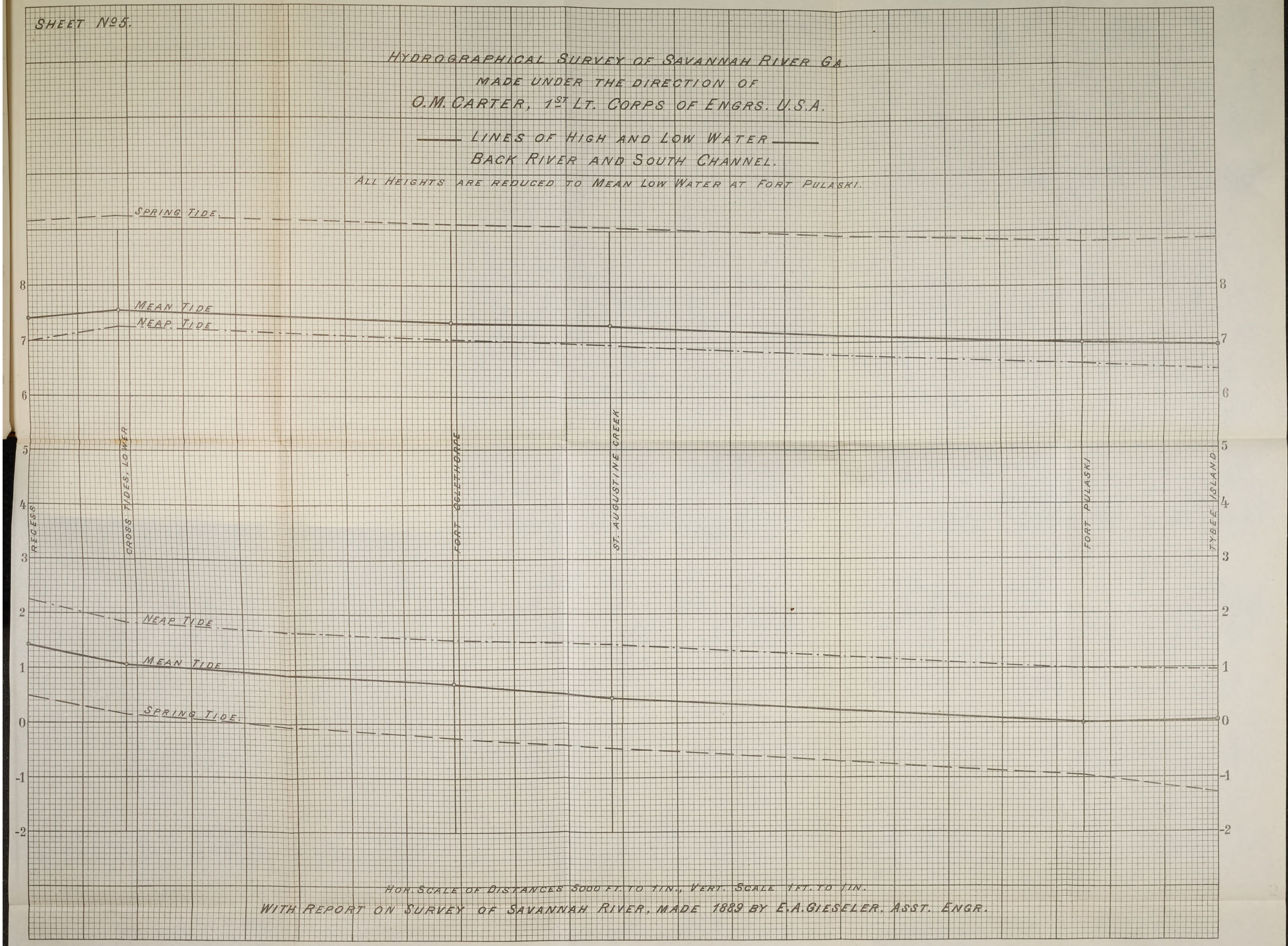
MADE UNDER THE DIRECTION OF

O.M. CARTER, 1ST LT. CORPS OF ENGRS. U.S.A.

LINES OF HIGH AND LOW WATER

BACK RIVER AND SOUTH CHANNEL.

ALL HEIGHTS ARE REDUCED TO MEAN LOW WATER AT FORT PULASKI.



HOR. SCALE OF DISTANCES 5000 FT. TO 1 IN., VERT. SCALE 1 FT. TO 1 IN.

WITH REPORT ON SURVEY OF SAVANNAH RIVER, MADE 1889 BY E.A. GIESELER, ASST. ENGR.

SHEET Nº 6.

HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER GA.

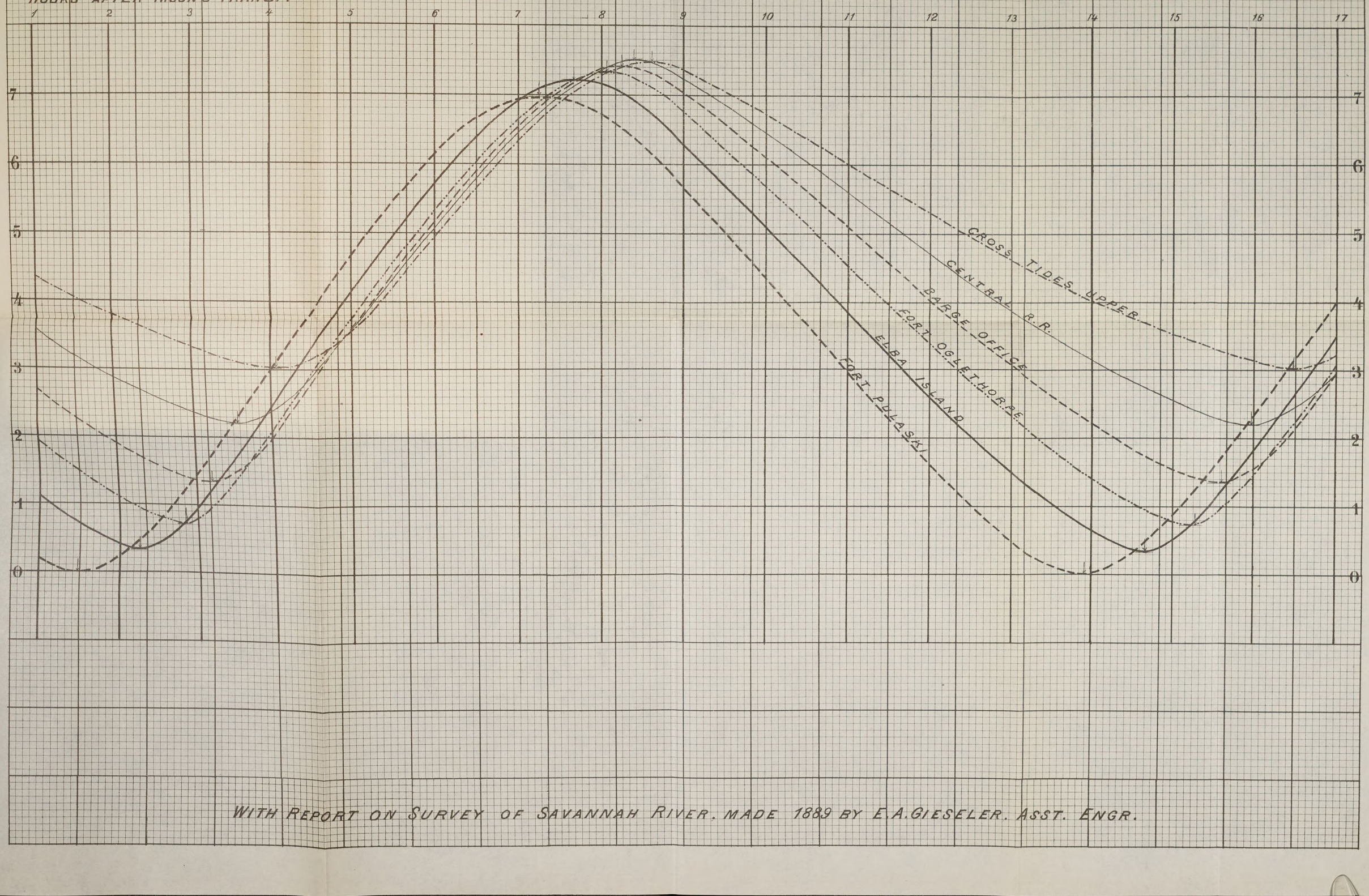
MADE UNDER THE DIRECTION OF

O.M. CARTER, 1ST LT. CORPS OF ENGRS. U.S.A.

MEAN TIDAL CURVES

FRONT RIVER AND NORTH CHANNEL

ALL HEIGHTS ARE REDUCED TO MEAN LOW WATER AT FORT PULASKI



WITH REPORT ON SURVEY OF SAVANNAH RIVER. MADE 1889 BY E.A.GIESELER. ASST. ENGR.

HOLAS AFTER MOON'S TRANSIT

SHEET NO. 8

SHEET Nº 7.

HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER GA.

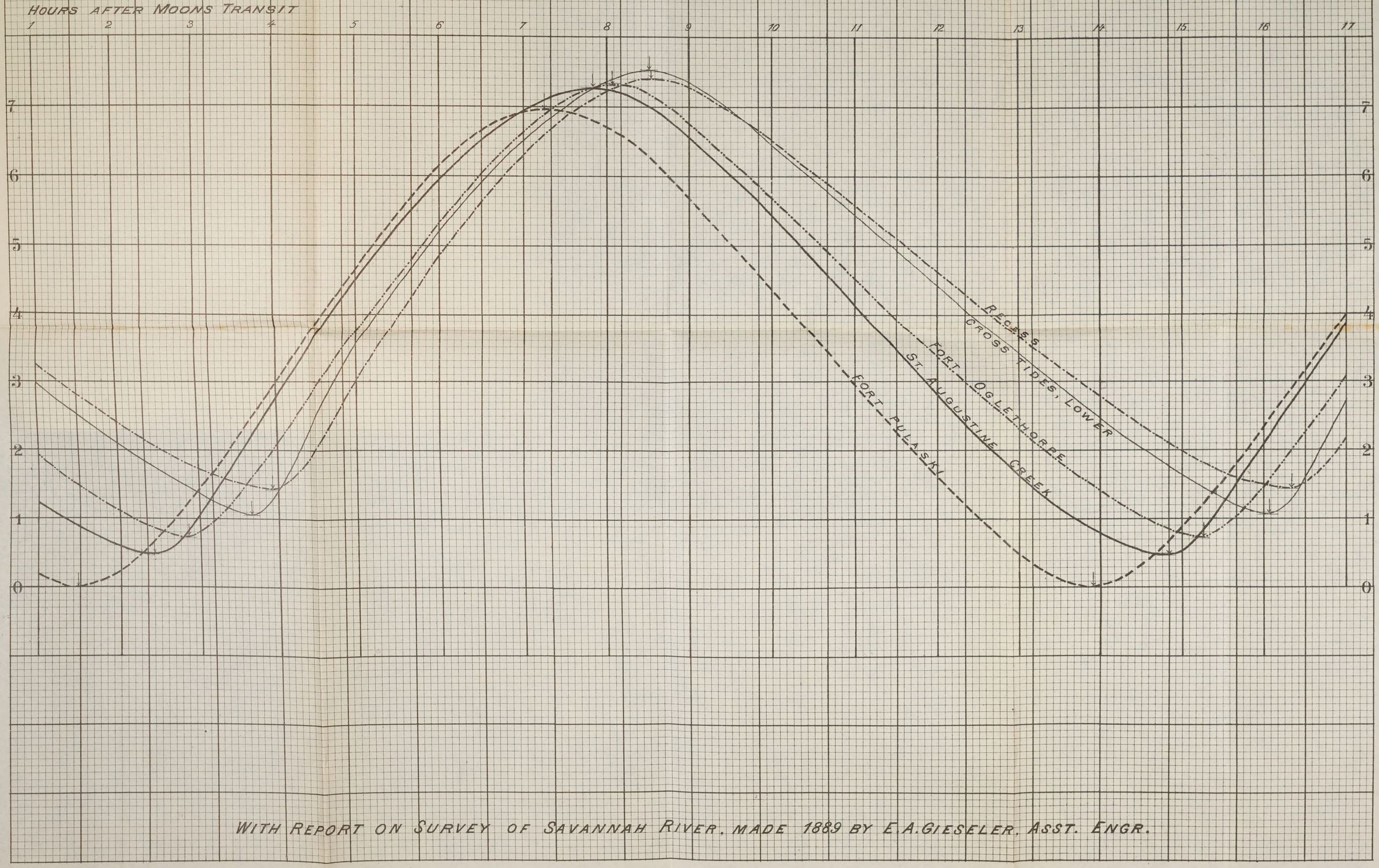
MADE UNDER THE DIRECTION OF

O.M. CARTER, 1ST LT. CORPS OF ENGRS. U.S.A.

MEAN TIDAL CURVES

BACK RIVER AND SOUTH CHANNEL

ALL HEIGHTS ARE REDUCED TO MEAN LOW WATER AT FORT PULASKI



WITH REPORT ON SURVEY OF SAVANNAH RIVER. MADE 1889 BY E.A. GIESELER, ASST. ENGR.

SHEET No 8.

HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER GA.

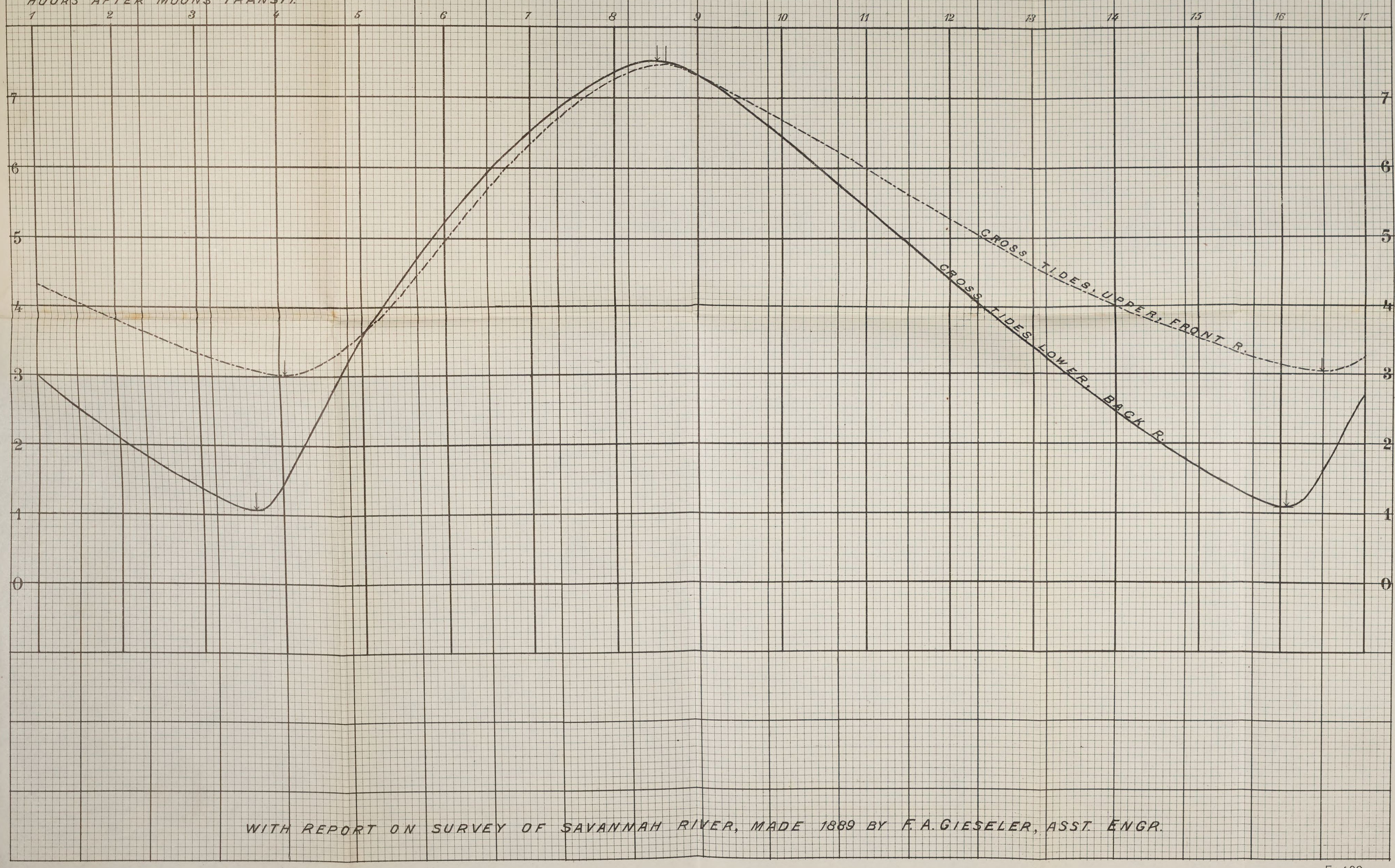
MADE UNDER THE DIRECFION OF

O. M. CARTER, 1ST. LT. CORPS OF ENGRS. U. S. A.

MEAN TIDAL CURVES

CROSS TIDES.

ALL HEIGHTS ARE REDUCED TO MEAN LOW WATER AT FORT PULASKI



WITH REPORT ON SURVEY OF SAVANNAH RIVER, MADE 1889 BY F. A. GIESELER, ASST. ENGR.

Eng 90

SHEET No 9.

HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER GA.

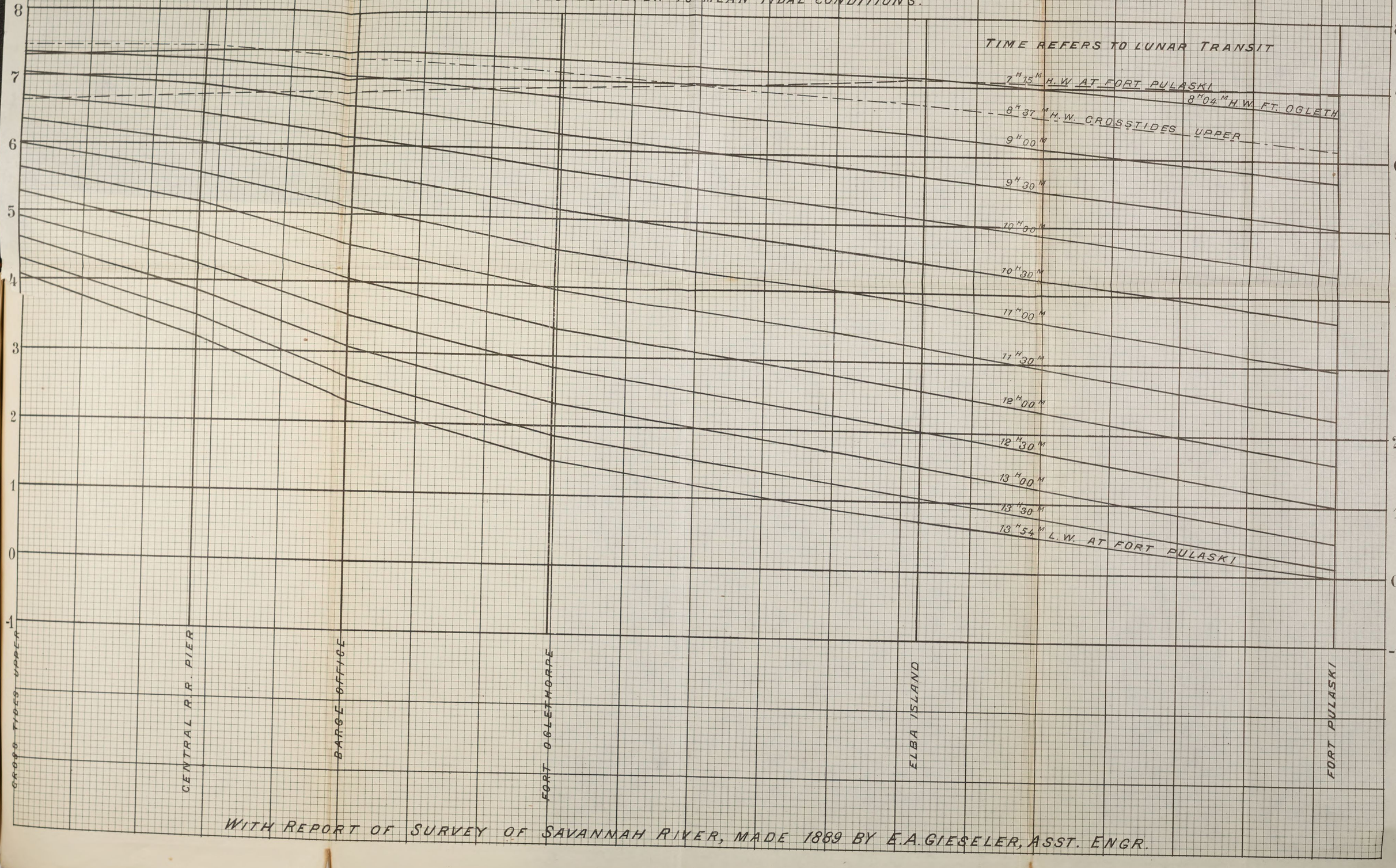
MADE UNDER THE DIRECTION OF

O. M. CARTER, 1ST LT. CORPS OF ENGRS U.S.A.

EBB SURFACE SLOPES

FRONT RIVER AND NORTH CHANNEL

ALL HEIGHTS ARE REDUCED TO MEAN LOW WATER AT FORT PULASKI
HOR. SCALE OF DISTANCES 5000 FT TO 1 IN, VERT. SCALE 1 FT. TO 1 IN.
ALL SLOPES REFER TO MEAN TIDAL CONDITIONS.



WITH REPORT OF SURVEY OF SAVANNAH RIVER, MADE 1889 BY E.A. GIESELER, ASST. ENGR.

SHEET NO 6

SHEET Nº 10

HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER GA.

MADE UNDER THE DIRECTION OF

O.M. CARTER, 1ST LT. CORPS OF ENGRS. U.S.A.

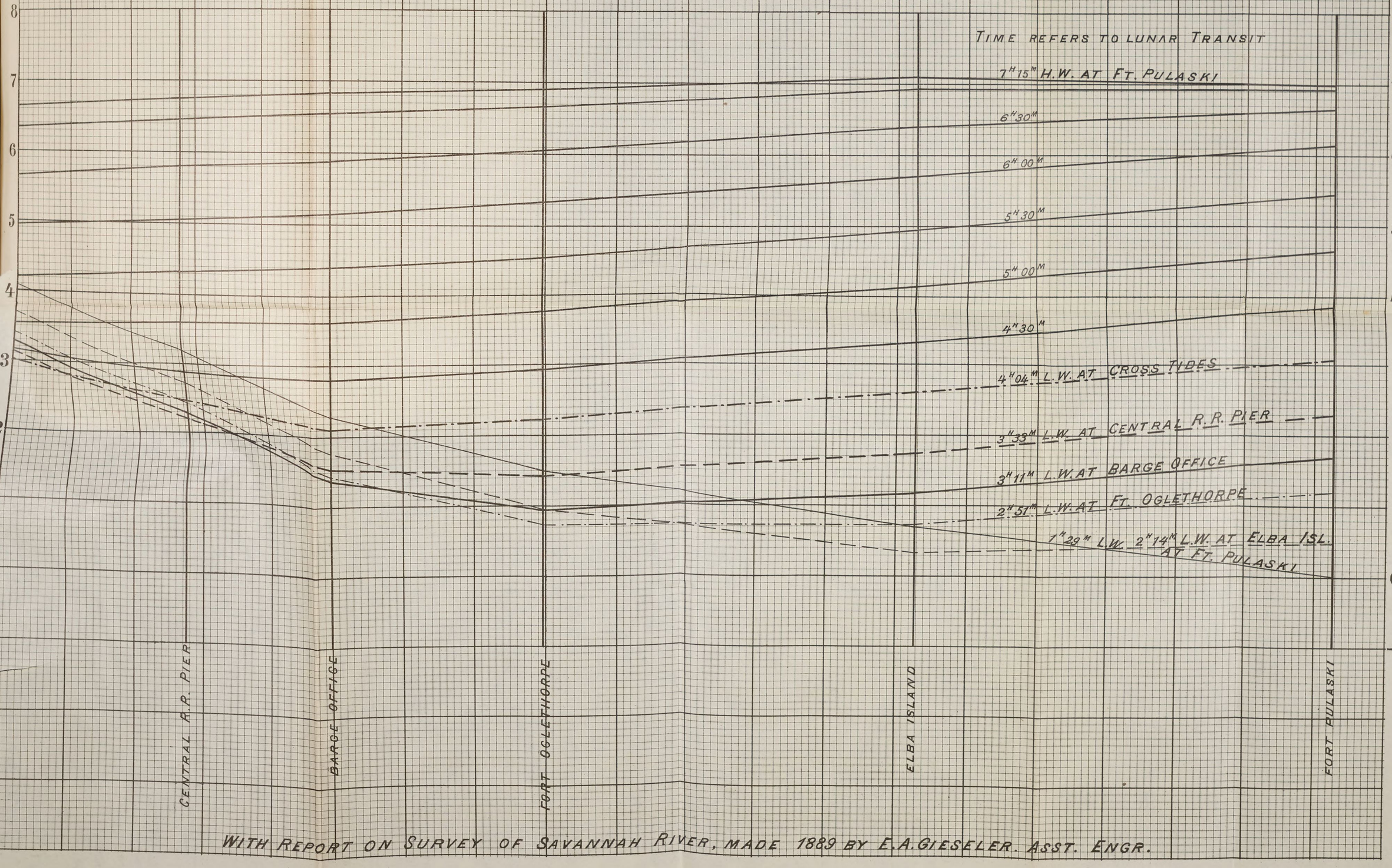
FLOOD SURFACE SLOPES

FRONT RIVER AND NORTH CHANNEL

ALL HEIGHTS ARE REDUCED TO MEAN LOW WATER AT FORT PULASKI

HOR. SCALE OF DISTANCES 5000 FT TO 1 IN., VERT. SCALE 1 FT. TO 1 IN.

ALL SLOPES REFER TO MEAN TIDAL CONDITIONS



WITH REPORT ON SURVEY OF SAVANNAH RIVER, MADE 1889 BY E.A. GIESELER. ASST. ENGR.

SHEET No. 10

SHEET Nº 11.

HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER GA.

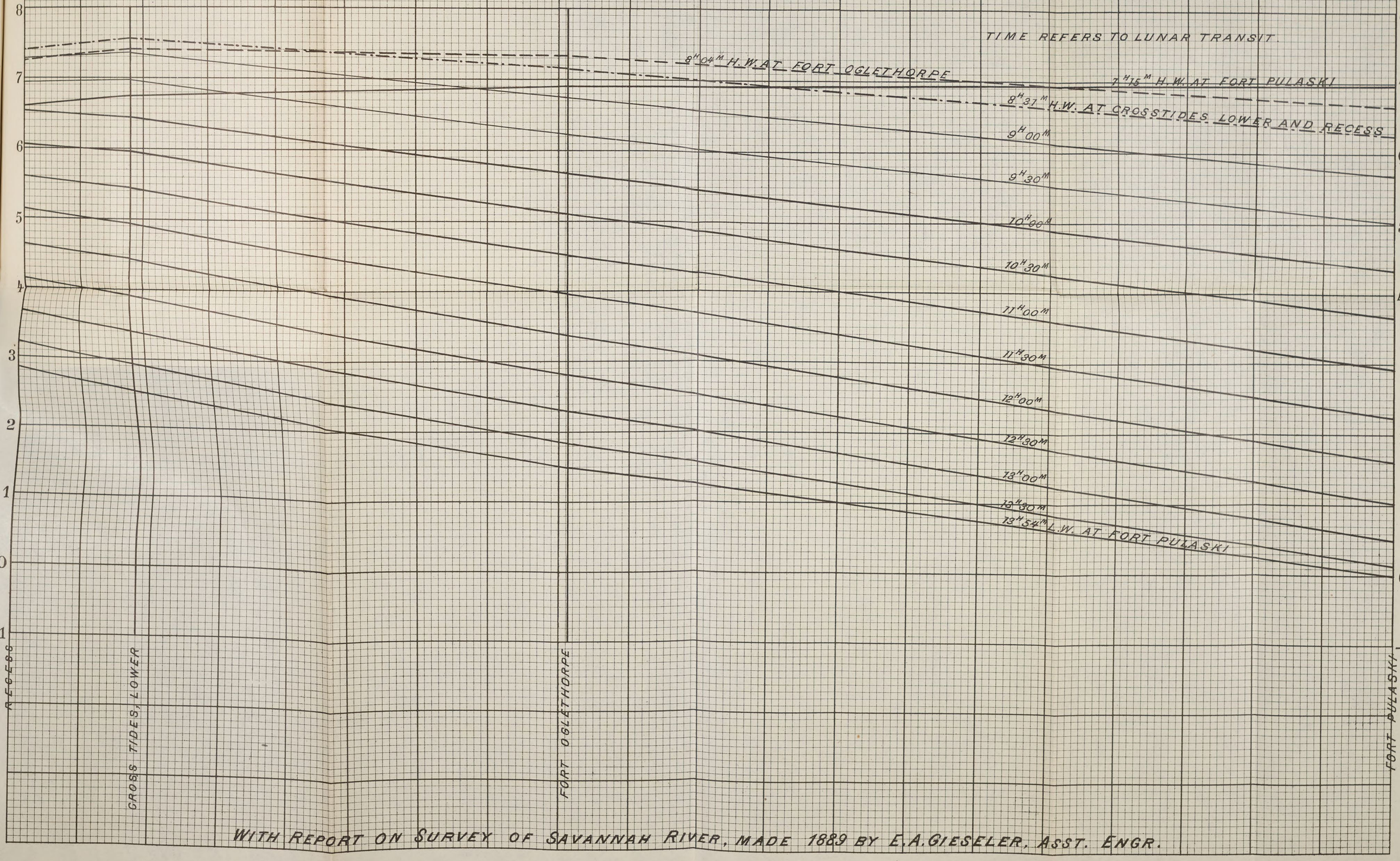
MADE UNDER THE DIRECTION OF

O.M. CARTER, 1ST LT. CORPS OF ENGRS. U.S.A.

EBB SURFACE SLOPES

BACK RIVER AND SOUTH CHANNEL

ALL HEIGHTS ARE REDUCED TO MEAN LOW WATER AT FORT PULASKI
HOR. SCALE OF DISTANCES 5000 FT. TO 1 IN., VERT. SCALE 1 FT. TO 1 IN.
ALL SLOPES REFER TO MEAN TIDAL CONDITIONS



WITH REPORT ON SURVEY OF SAVANNAH RIVER, MADE 1889 BY E.A. GIESELER, ASST. ENGR.

SHEET NOTE

SHEET Nº12.

HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER GA.

MADE UNDER THE DIRECTION OF

O.M. CARTER, 1ST LT. CORPS OF ENGRS. U.S.A.

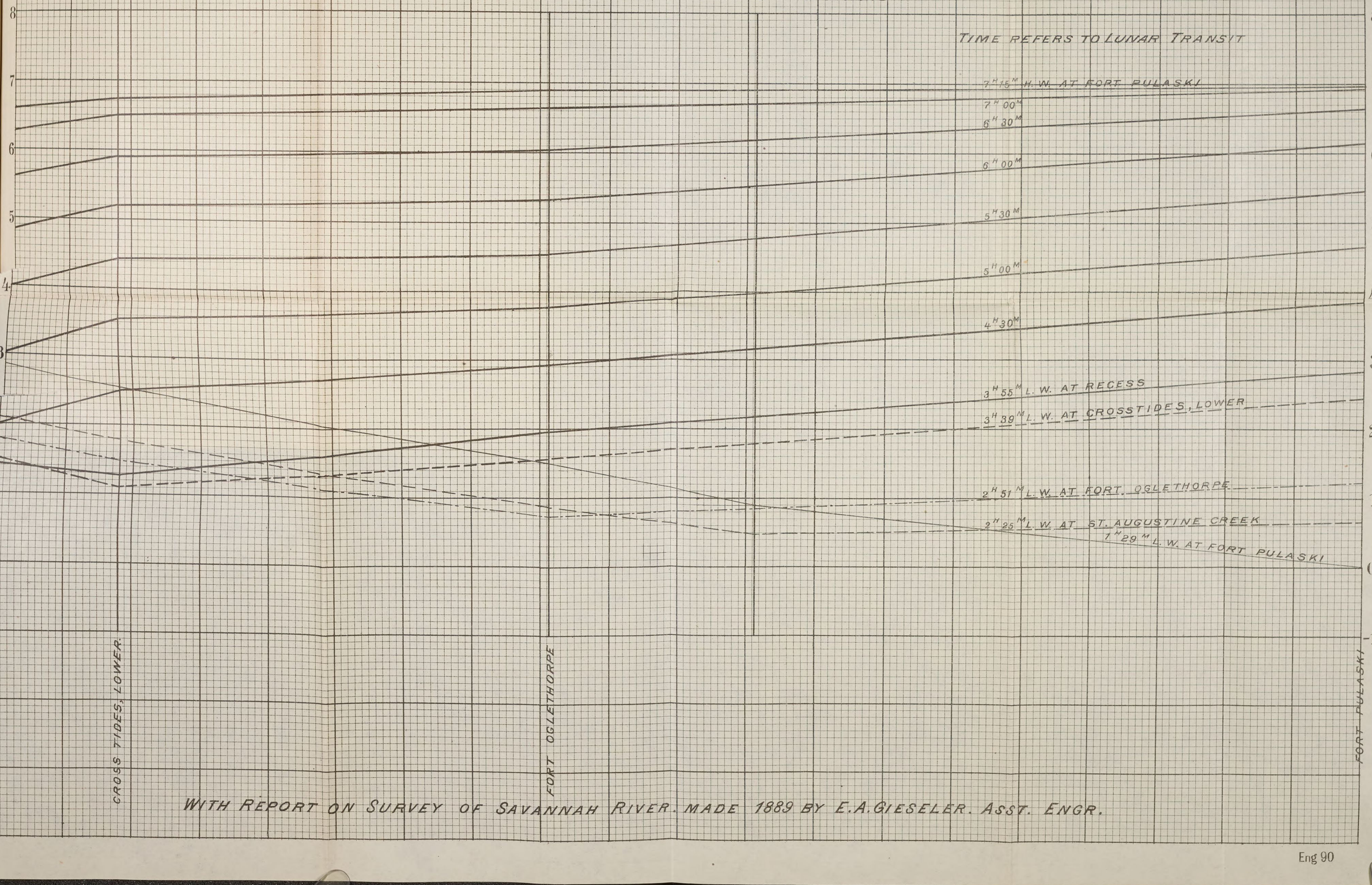
FLOOD SURFACE SLOPES

BACK RIVER AND SOUTH CHANNEL

ALL HEIGHTS ARE REDUCED TO MEAN LOW WATER AT FORT PULASKI

HOR. SCALE OF DISTANCES 5000 FT. TO 1 IN, VERT. SCALE 1 FT. TO 1 IN.

ALL SLOPES REFER TO MEAN TIDAL CONDITIONS



WITH REPORT ON SURVEY OF SAVANNAH RIVER. MADE 1889 BY E.A. GIESELER. ASST. ENGR.

SHEET Nº 13

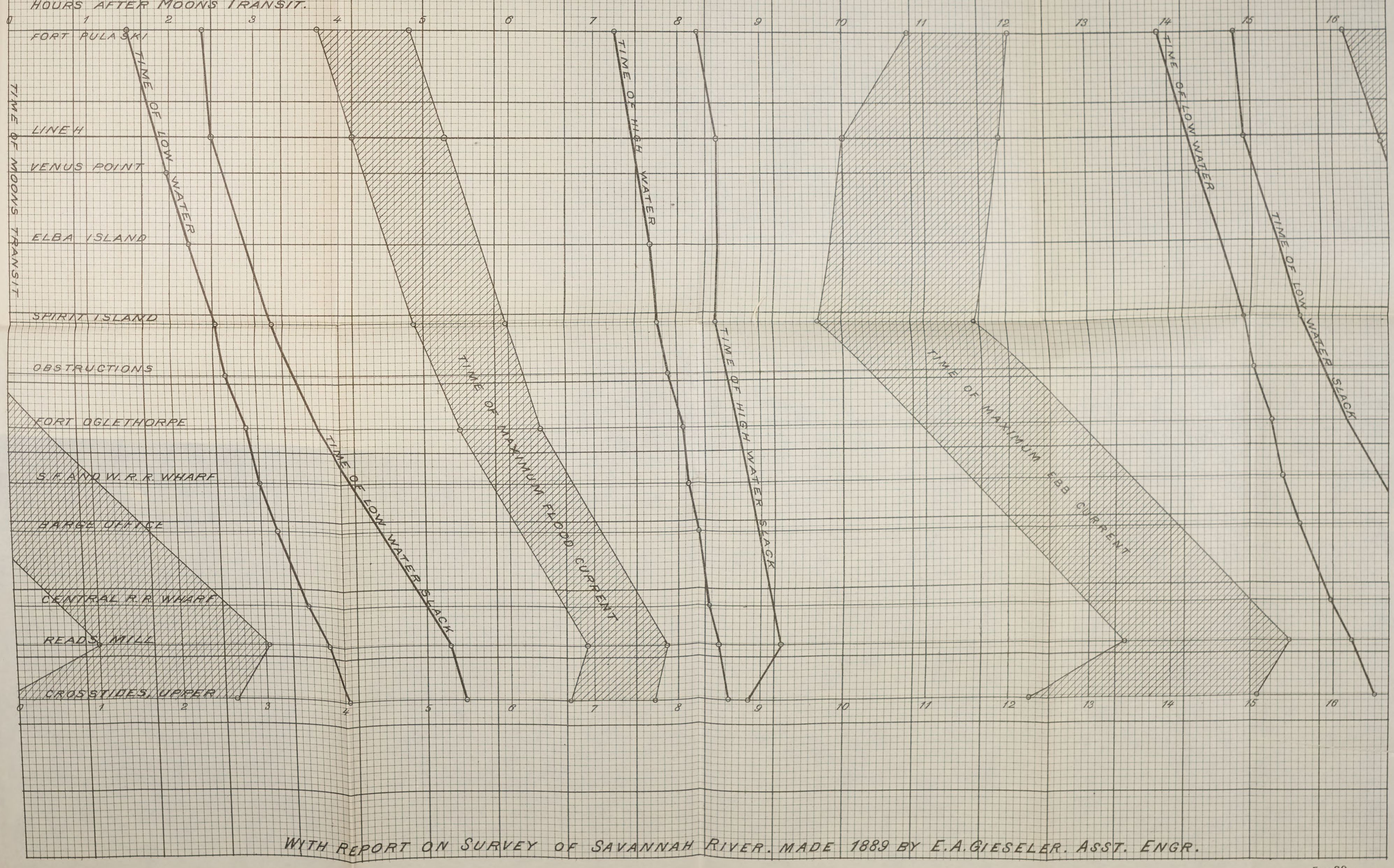
HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER GA.

MADE UNDER THE DIRECTION OF

O.M. CARTER, 1ST LT. CORPS OF ENGRS. U.S.A.

CHRONOLOGY OF TIDAL PHENOMENA

FRONT RIVER AND NORTH CHANNEL



WYTH REPORT ON SURVEY OF SAVANNAH RIVER. MADE 1889 BY E.A. GIESELER. ASST. ENGR.

Eng 90.

SHEET Nº 14.

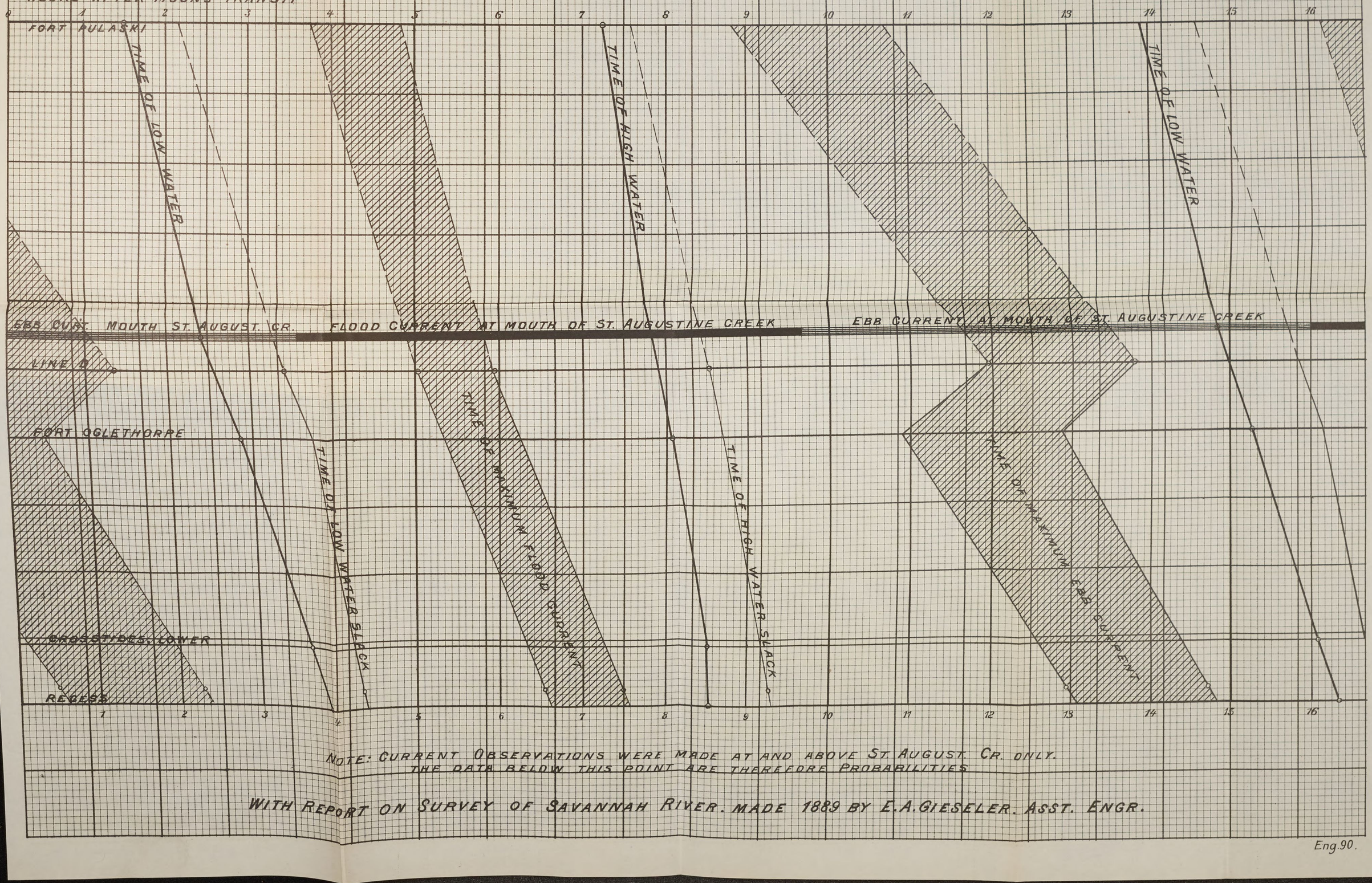
HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER GA.

MADE UNDER THE DIRECTION OF

O.M. CARTER, 1ST LT. CORPS OF ENGRS. U.S.A.

CHRONOLOGY OF TIDAL PHENOMENA

BACK RIVER AND SOUTH CHANNEL.



NOTE: CURRENT OBSERVATIONS WERE MADE AT AND ABOVE ST. AUGUST. CR. ONLY.
THE DATA BELOW THIS POINT ARE THEREFORE PROBABILITIES.

WITH REPORT ON SURVEY OF SAVANNAH RIVER. MADE 1889 BY E.A. GIESELER. ASST. ENGR.

Eng. 90.

SHEET Nº 15.

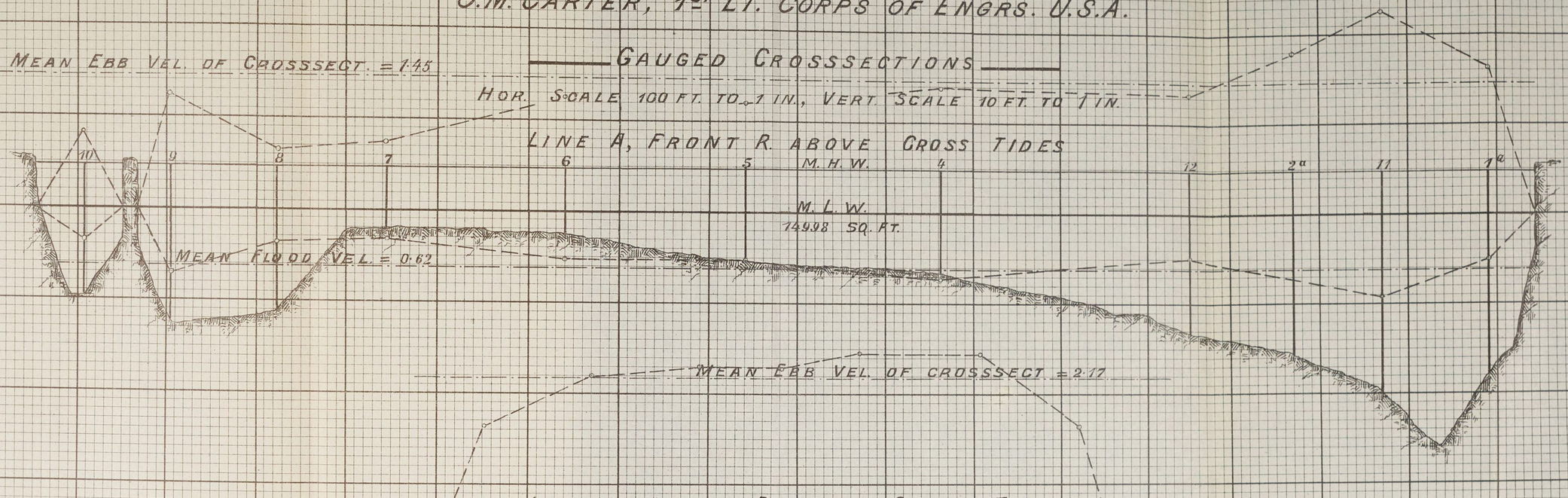
HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER GA.

MADE UNDER THE DIRECTION OF

O.M. CARTER, 1ST LT. CORPS OF ENGRS. U.S.A.

GAUGED CROSSSECTIONS

HOR. SCALE 100 FT. TO 1 IN., VERT. SCALE 10 FT. TO 1 IN.



NOTE. MEAN VELOCITIES ARE SHOWN IN A SCALE OF 1 FT. PER SECOND TO 1 IN., IN A BROKEN LINE, THE EBB FROM M.L.W. UPWARD, THE FLOOD DOWNWARD. THEY ARE CORRECTED TO MEAN CONDITIONS OF TIDE AND FRESH WATER FLOW.

WITH REPORT ON SURVEY OF SAVANNAH RIVER. MADE 1889 BY E.A. GIESELER, ASST. ENGR.

Eng. 90.

SHEET Nº 16.

HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER GA.

MADE UNDER THE DIRECTION OF

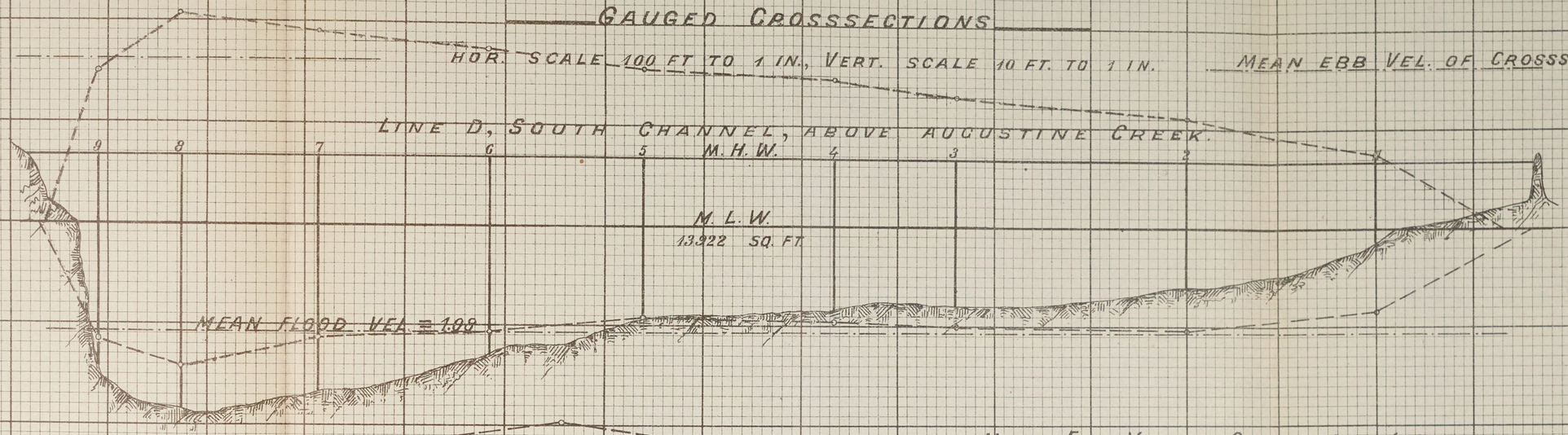
O. M. CARTER, 1ST LT. CORPS OF ENGRS. U.S.A.

GAUGED CROSSSECTIONS

HOR. SCALE 100 FT TO 1 IN., VERT. SCALE 10 FT. TO 1 IN.

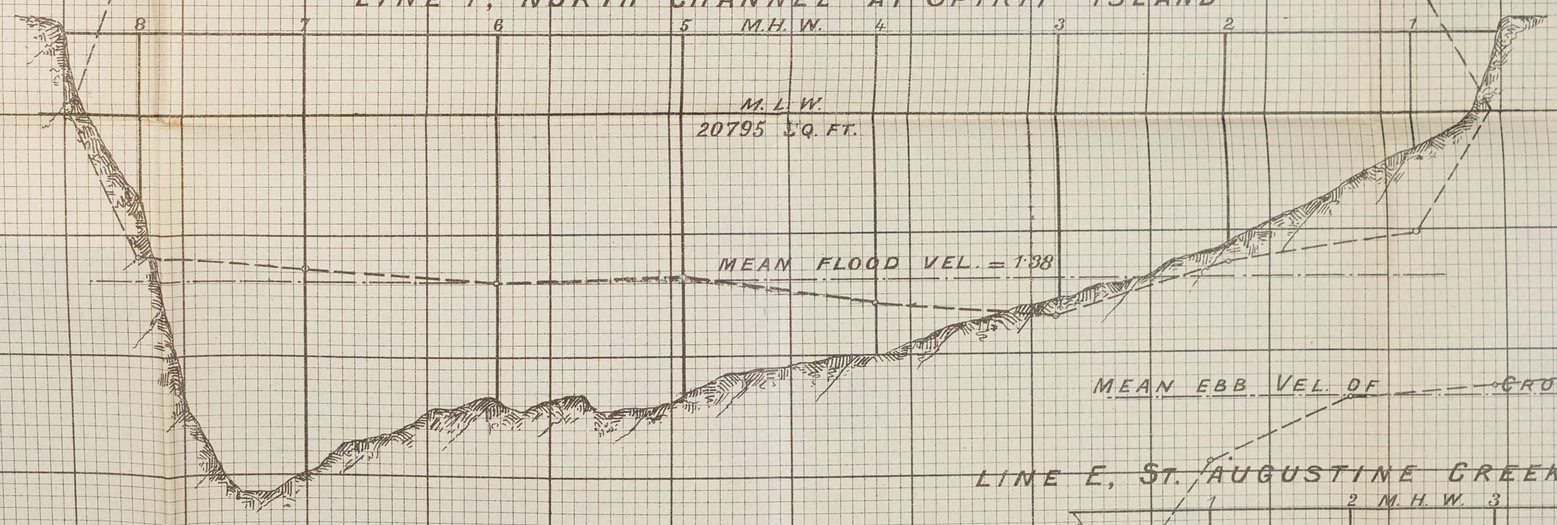
MEAN EBB VEL. OF CROSSSECT. = 1·63

LINE D, SOUTH CHANNEL, ABOVE AUGUSTINE CREEK.



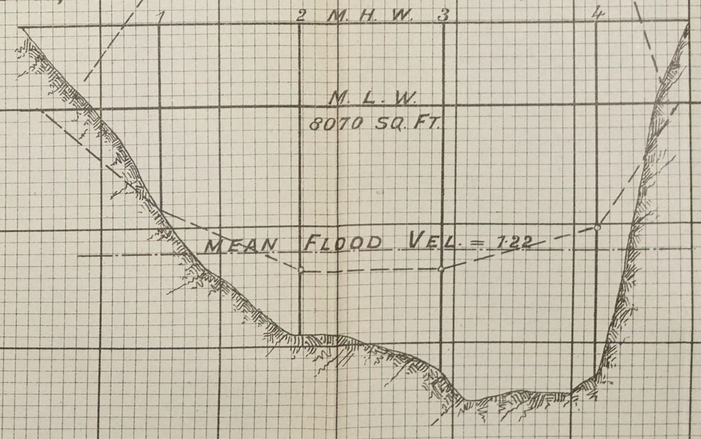
MEAN EBB VEL. OF CROSSSECT. = 1·76

LINE F, NORTH CHANNEL AT SPIRIT ISLAND



MEAN EBB VEL. OF CROSSSECT. = 1·61

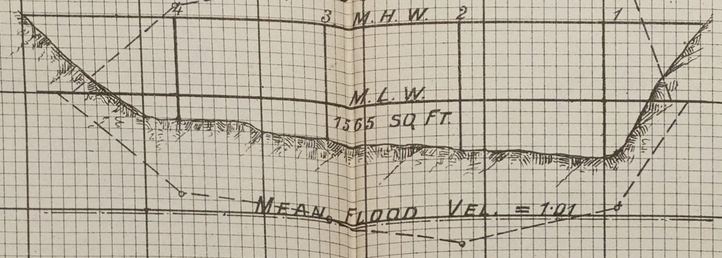
LINE E, ST. AUGUSTINE CREEK, NEAR BRIDGE



NOTE. MEAN VELOCITIES ARE SHOWN IN A SCALE OF 1 FT. PER SECOND TO 1 IN., IN A BROKEN LINE, THE EBB FROM M.L.W. UPWARD, THE FLOOD DOWNWARD. THEY ARE CORRECTED TO MEAN CONDITIONS OF TIDE AND FRESH WATER FLOW.

MEAN EBB VEL. OF CROSSSECT. = 1·16

LINE G, DUCK PUDDLE



WITH REPORT ON SURVEY OF SAVANNAH RIVER, MADE 1889 BY E.A. GLESELER, ASST. ENGR.

Eng. 90.

SHEET No 19

SHEET Nº 17.

HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER GA.

MADE UNDER THE DIRECTION OF

O. M. CARTER, 1ST LT. CORPS OF ENGRS U.S.A.

EXAMPLE SHOWING METHOD OF PLATTING CURRENT METER OBSERVATIONS

LINE F. VERT. 2. MAY 11. 1889.

HOR. SCALE OF TIME 1 HOUR TO 1 IN., VERT. SCALE OF VELOCITIES PER SECOND 1 FT. TO 1 IN.
EBB VELOCITIES ARE SHOWN FROM ZERO LINE UPWARD, FLOOD VEL. DOWNWARD

WITH REPORT ON SURVEY OF SAVANNAH RIVER, MADE 1889 BY E.A.GIESELER, ASST. ENGR.

Eng. 90.

SHEET Nº18.

HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER GA.

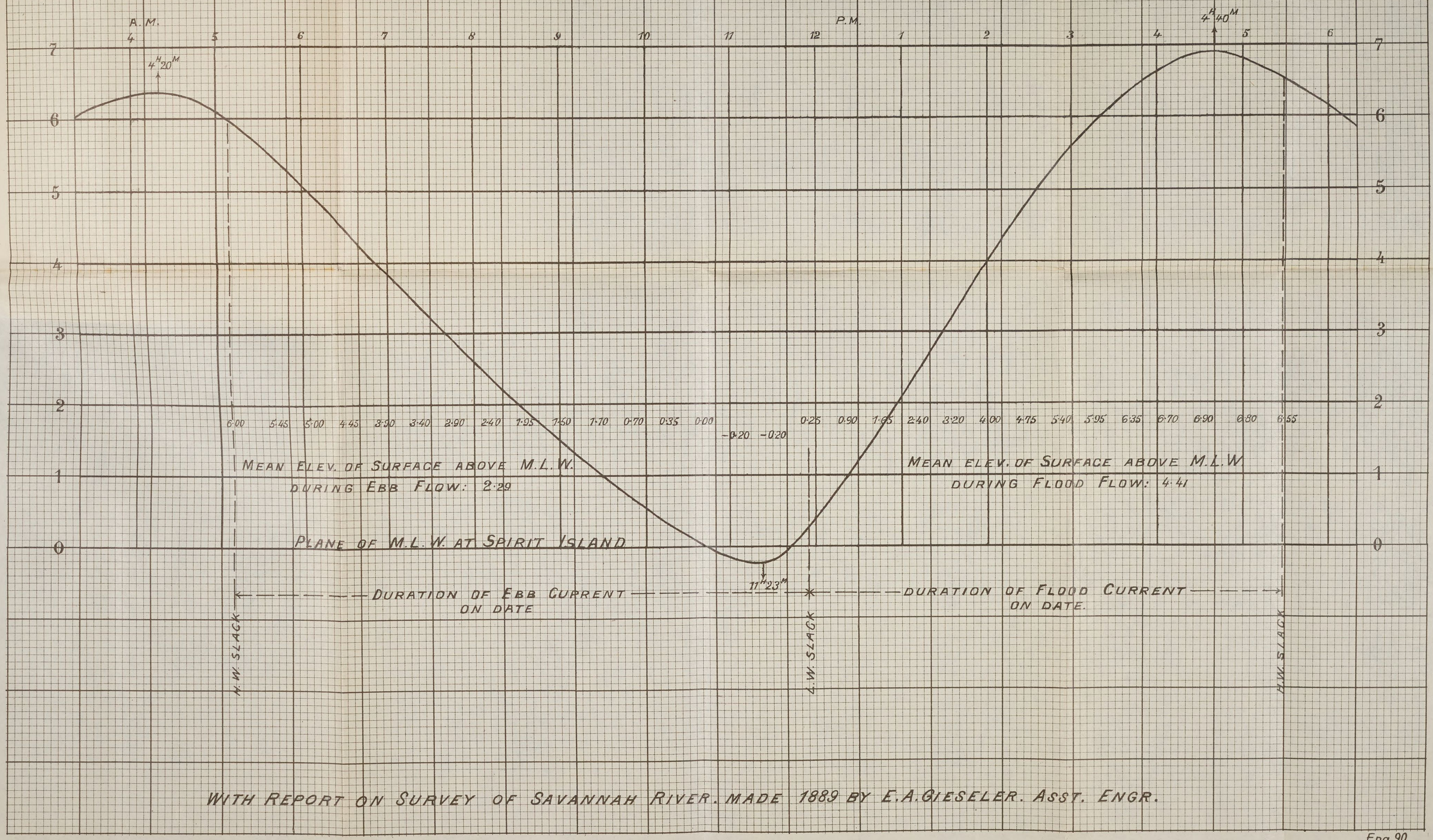
MADE UNDER THE DIRECTION OF

O.M. CARTER, 1ST LT. CORPS OF ENGRS. U.S.A.

EXAMPLE SHOWING METHOD OF DETERMINING MEAN ELEVATION OF SURFACE ABOVE MEAN LOW WATER, DURING EBB AND FLOOD FLOW

THE OBSERVATIONS ARE REDUCED TO LOCAL MEAN LOW WATER.

TIDAL OBSERVATIONS AT
SPIRIT ISLAND, MAY 11 1889.



WITH REPORT ON SURVEY OF SAVANNAH RIVER. MADE 1889 BY E.A. GIESELER. ASST. ENGR.



HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER GA.

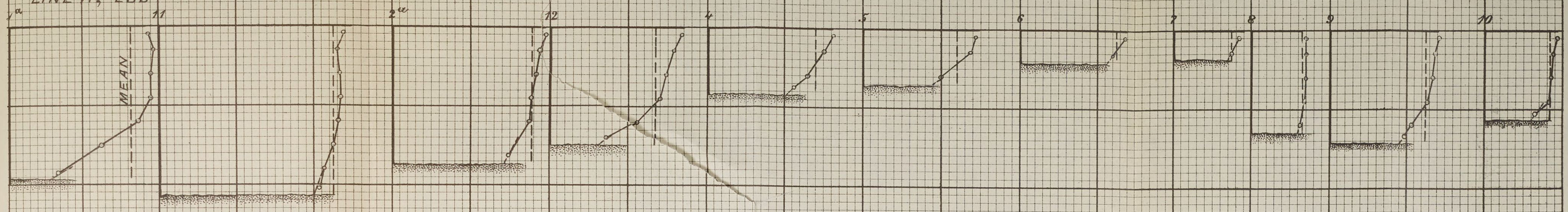
SHEET Nº 19.

MADE UNDER THE DIRECTION OF

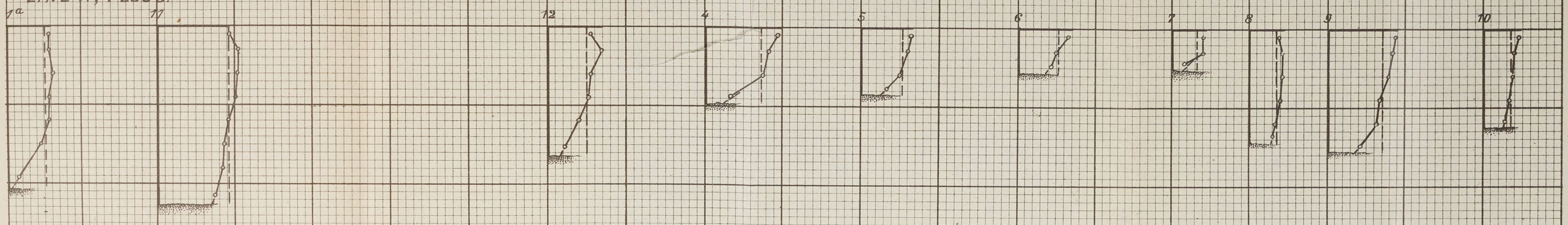
O.M. CARTER, 1ST LT. CORPS OF ENGRS. U.S.A.

MEAN EBB AND FLOOD VELOCITIES AT DIFFERENT DEPTHS

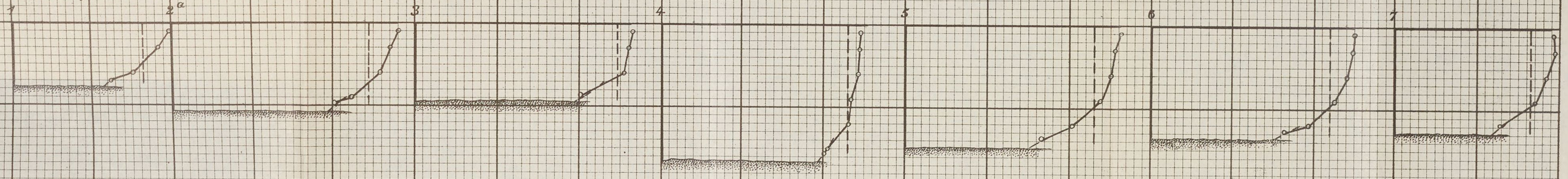
LINE A, EBB



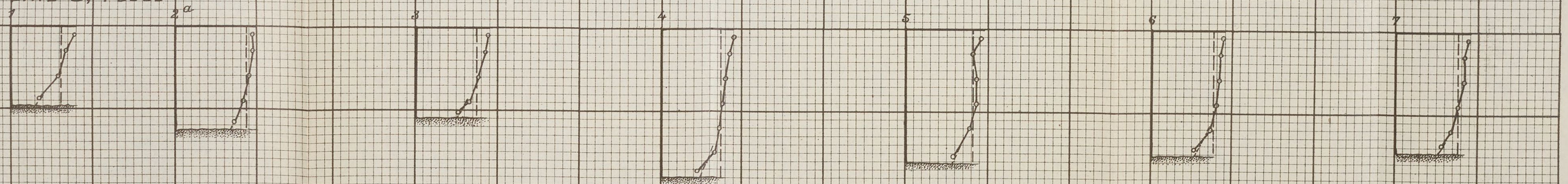
LINE A, FLOOD.



LINE B, EBB



LINE B, FLOOD



VELOCITIES ARE CORRECTED TO MEAN CONDITIONS OF TIDE AND OF FRESH WATER FLOW
VERT. SCALE OF DEPTHS 10 FT. TO 1 IN., HOR. SCALE OF VELOCITIES PER SECOND 1 FT. TO 1 IN.

WITH REPORT ON SURVEY OF SAVANNAH RIVER. MADE 1889 BY E.A. GIESELER. ASST. ENGR.

Eng. 90.

SHEET Nº 20.

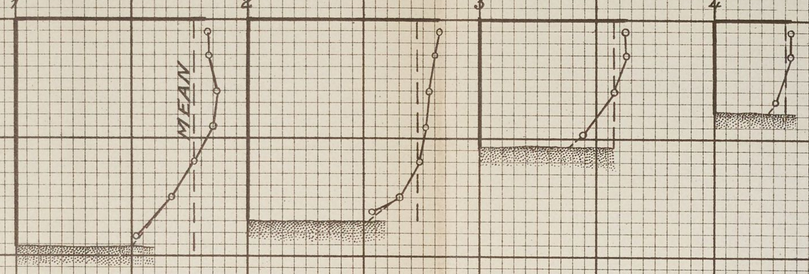
HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER GA.

MADE UNDER THE DIRECTION OF

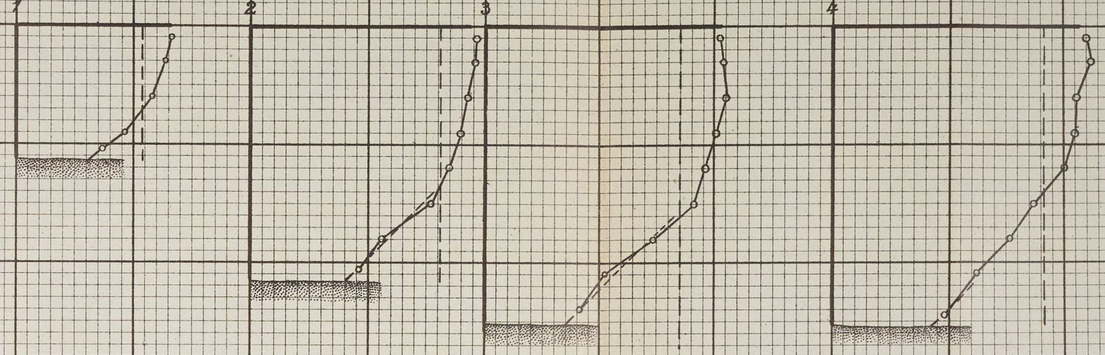
O.M. CARTER, 1st LT. CORPS OF ENGRS. U.S.A.

MEAN EBB AND FLOOD VELOCITIES AT DIFFERENT DEPTHS

LINE C, EBB



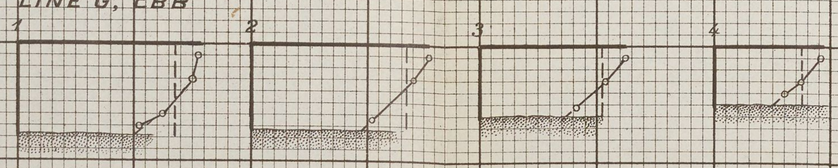
LINE E, EBB



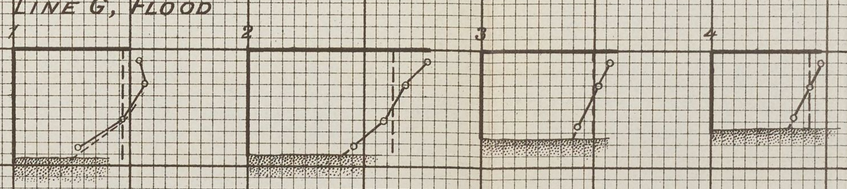
LINE C, FLOOD

LINE E, FLOOD

LINE G, EBB



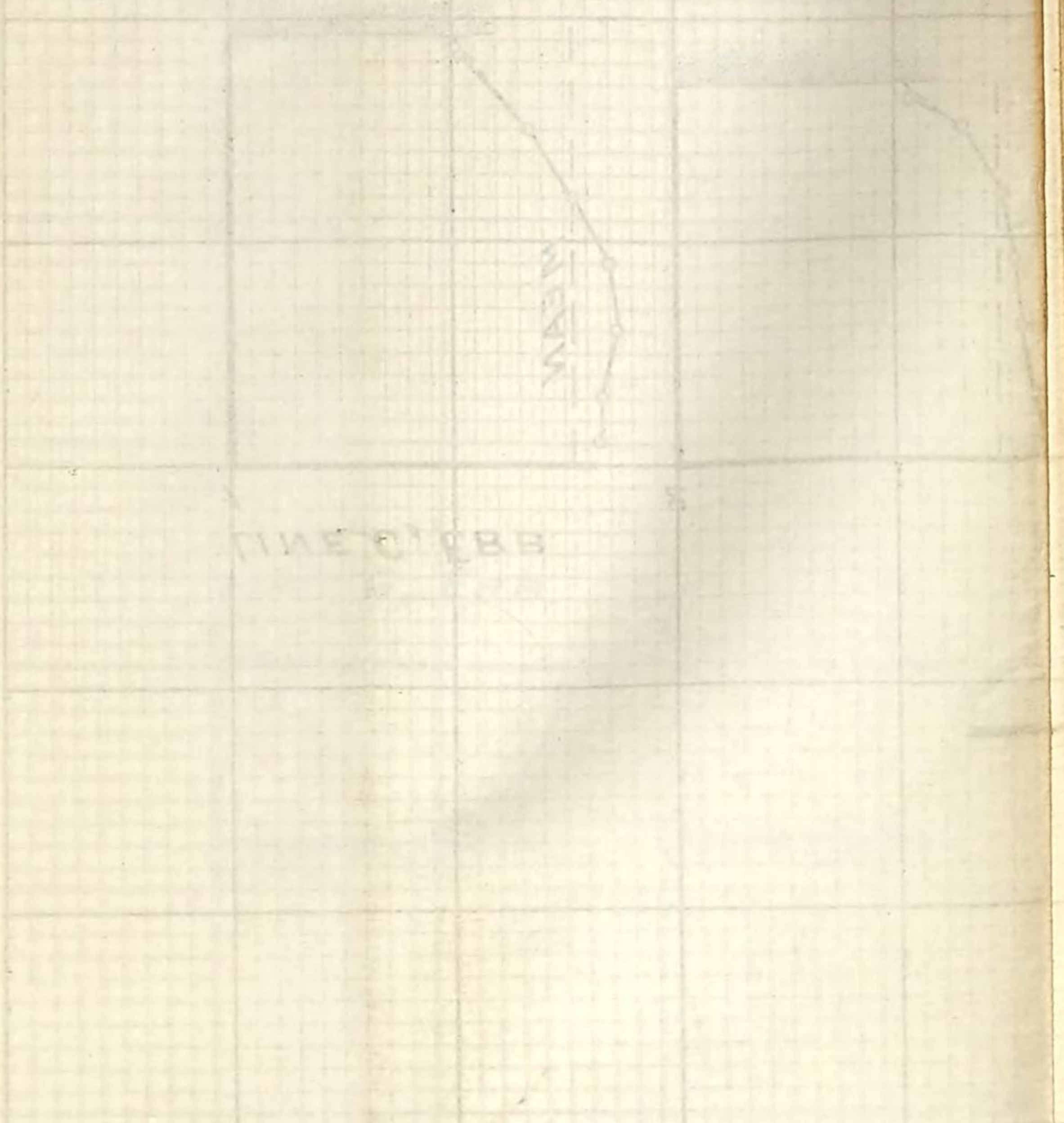
LINE G, FLOOD



VELOCITIES ARE CORRECTED TO MEAN CONDITIONS OF TIDE AND OF FRESH WATER FLOW
VERT. SCALE OF DEPTHS 10 FT. TO 1 IN., HOR. SCALE OF VELOCITIES PER SECOND 1 FT. TO 1 IN.

WITH REPORT ON SURVEY OF SAVANNAH RIVER, MADE 1889 BY E.A. GIESELER, ASST. ENGR.

Eng 90



HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER GA.

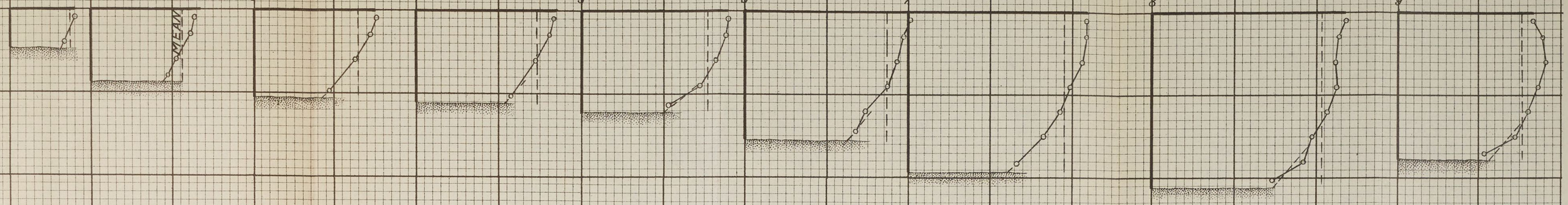
SHEET No. 21.

MADE UNDER THE DIRECTION OF

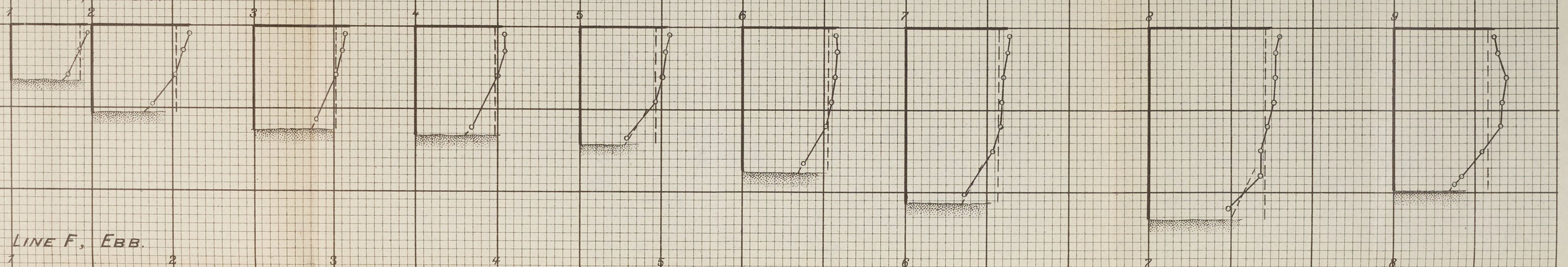
O.M. CARTER, 1ST LT. CORPS OF ENGRS. U.S.A.

MEAN EBB AND FLOOD VELOCITIES AT DIFFERENT DEPTHS

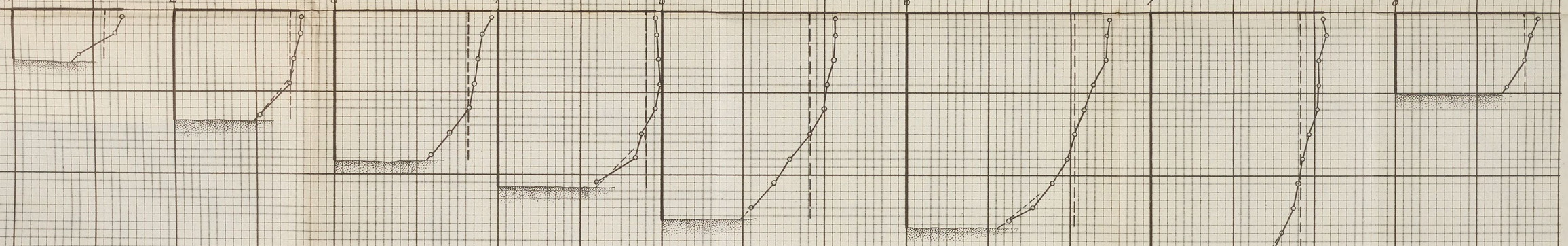
LINE D, EBB.



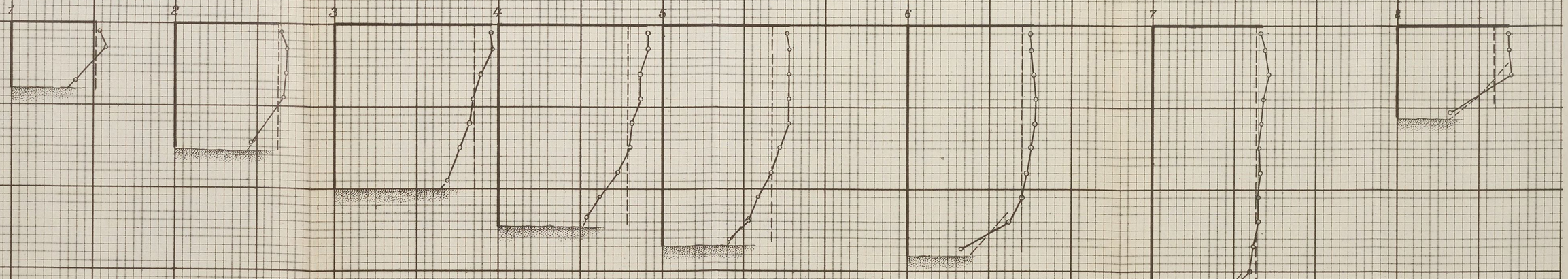
LINE D, FLOOD.



LINE F, EBB.



LINE F, FLOOD.



VELOCITIES ARE CORRECTED TO MEAN CONDITIONS OF TIDE AND OF FRESH WATER FLOW
VERT. SCALE OF DEPTHS 10FT. TO 1IN., HOR. SCALE OF VELOCITIES PER SECOND 1FT. TO 1IN.

WITH REPORT ON SURVEY OF SAVANNAH RIVER, MADE 1889 BY E.A. GIESELER. ASST. ENGR.

Eng 90

HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER GA.

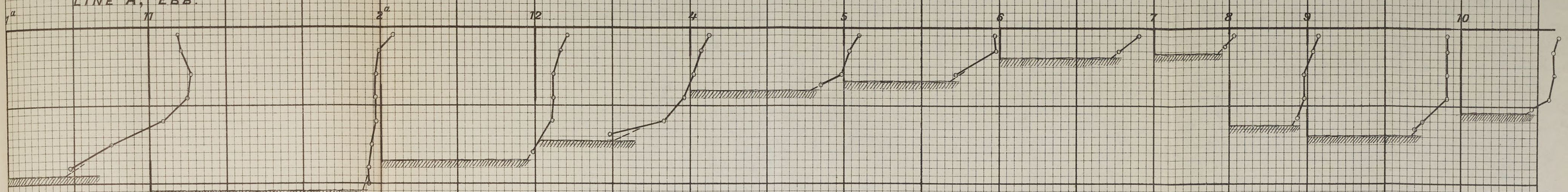
SHEET Nº 22.

MADE UNDER THE DIRECTION OF

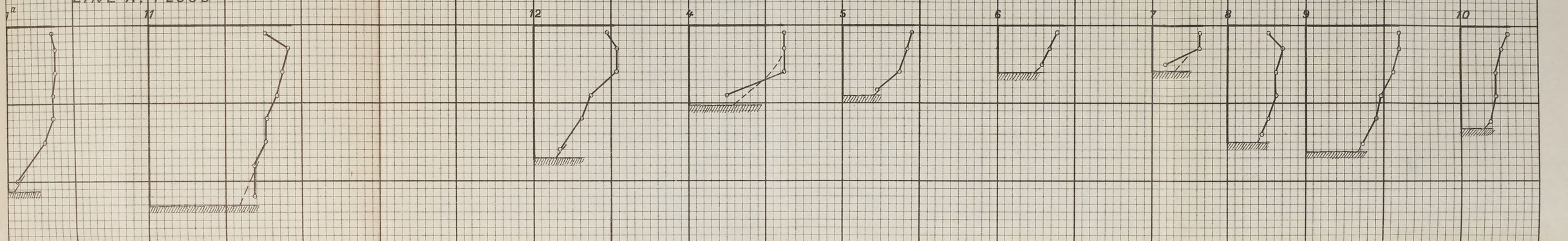
O.M. CARTER, 1ST LT. CORPS OF ENGRS. U.S.A.

MAXIMUM EBB AND FLOOD VELOCITIES AT DIFFERENT DEPTHS

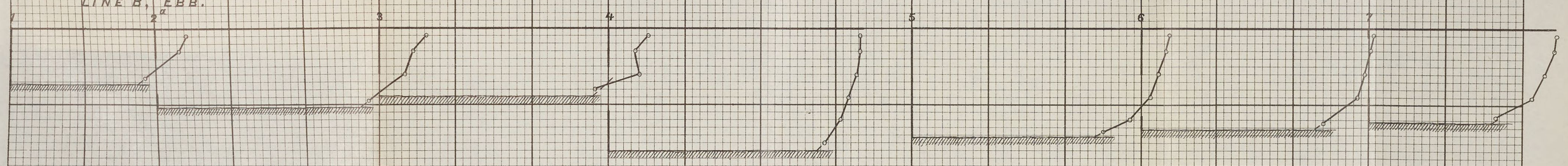
LINE A, EBB.



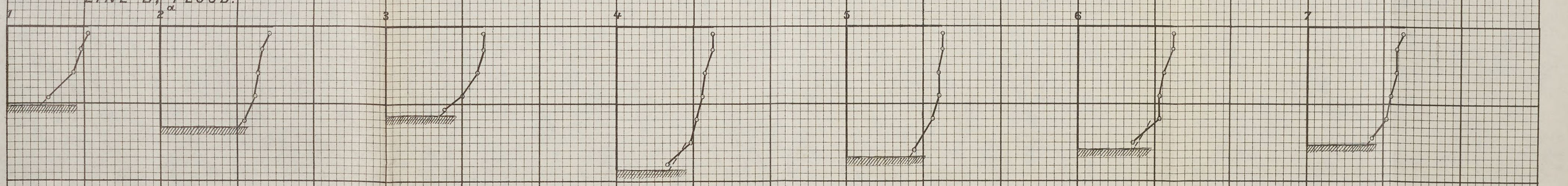
LINE A, FLOOD



LINE B, EBB.



LINE B, FLOOD.



VELOCITIES ARE CORRECTED TO MEAN CONDITIONS OF TIDE AND OF FRESH WATER FLOW
VERT. SCALE OF DEPTHS 10 FT. TO 1 IN., HOR. SCALE OF VELOCITIES PER SECOND 1 FT. TO 1 IN.

WITH REPORT ON SURVEY OF SAVANNAH RIVER, MADE 1889 BY E.A. GIESELER. ASST. ENGR.

SHEET Nº 23.

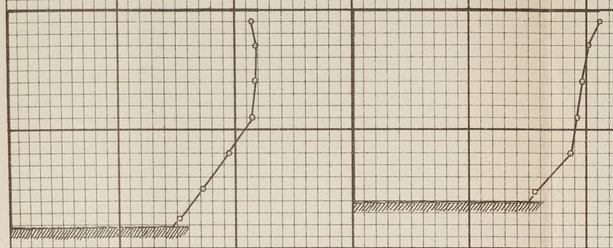
HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER GA.

MADE UNDER THE DIRECTION OF

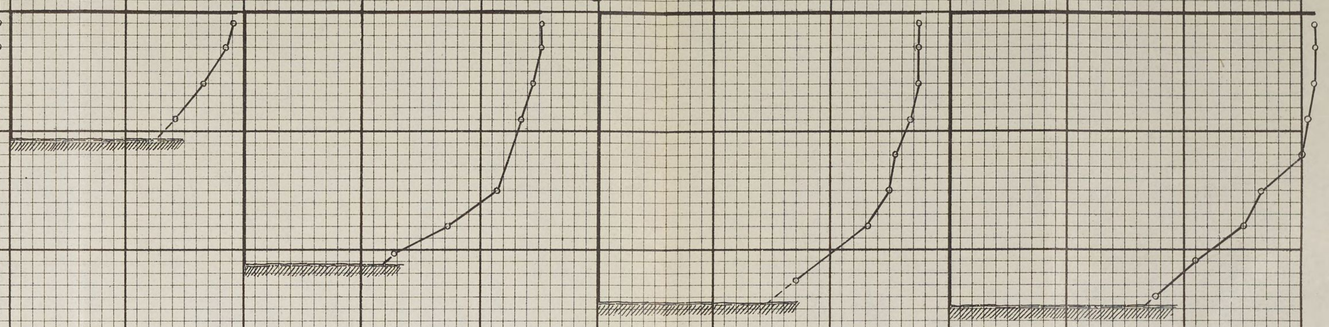
O.M. CARTER, 1ST LT. CORPS OF ENGRS. U.S.A.

MAXIMUM EBB AND FLOOD VELOCITIES AT DIFFERENT DEPTHS

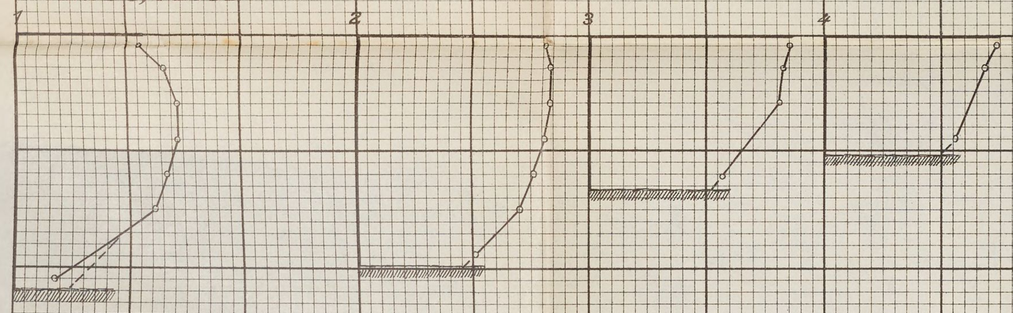
LINE C, EBB.



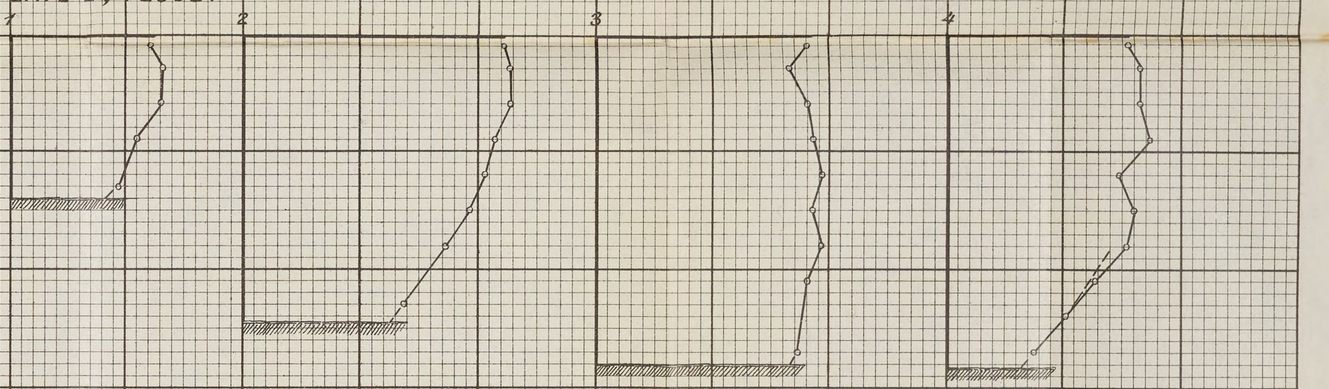
LINE, E, EBB.



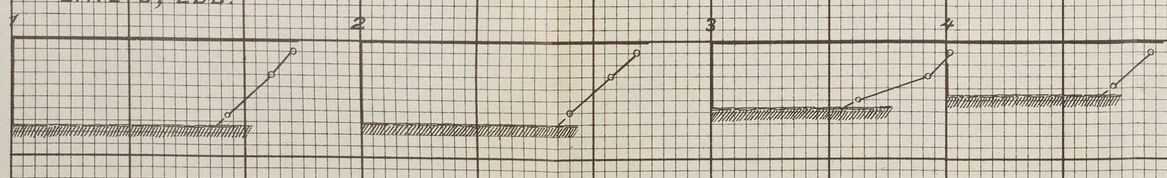
LINE C, FLOOD



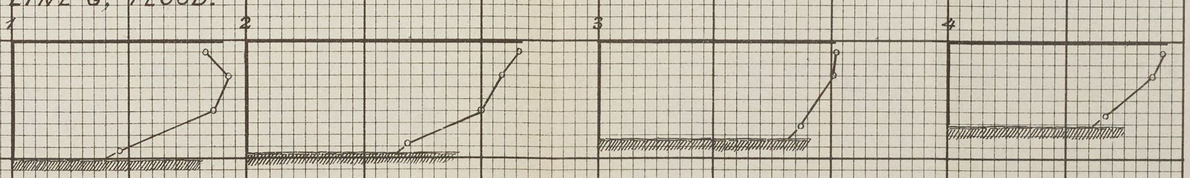
LINE E, FLOOD.



LINE G, EBB.



LINE G, FLOOD.



VELOCITIES ARE CORRECTED TO MEAN CONDITIONS OF TIDE AND OF FRESH WATER FLOW
VERT. SCALE OF DEPTHS 10 FT. TO 1 IN., HOR. SCALE OF VELOCITIES PER SECOND 1 FT. TO 1 IN.

WITH REPORT ON SURVEY OF SAVANNAH RIVER, MADE 1889 BY E.A. GIESELER. ASST. ENGR.

HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER GA.

SHEET No. 24.

MADE UNDER THE DIRECTION OF

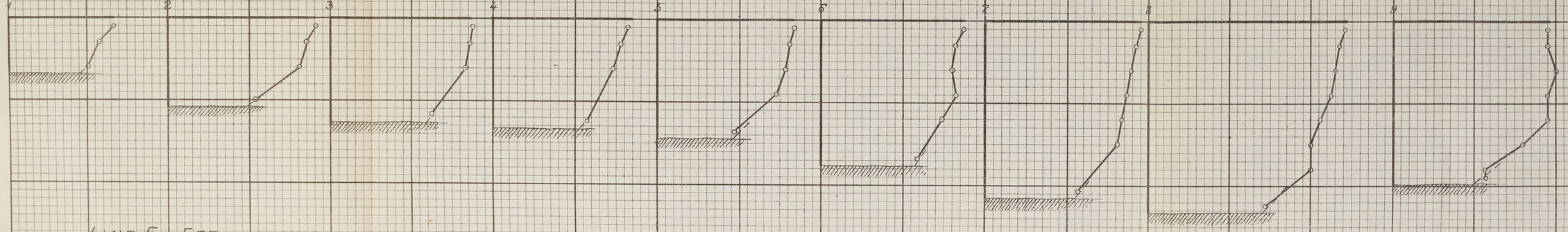
O.M. CARTER, 1ST LT. CORPS OF ENGRS. U.S.A.

MAXIMUM EBB AND FLOOD VELOCITIES AT DIFFERENT DEPTHS

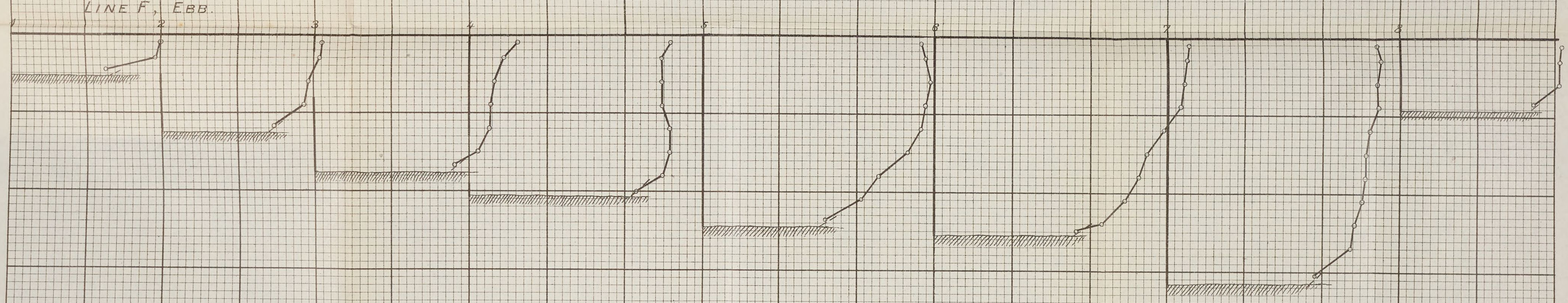
LINE D, EBB



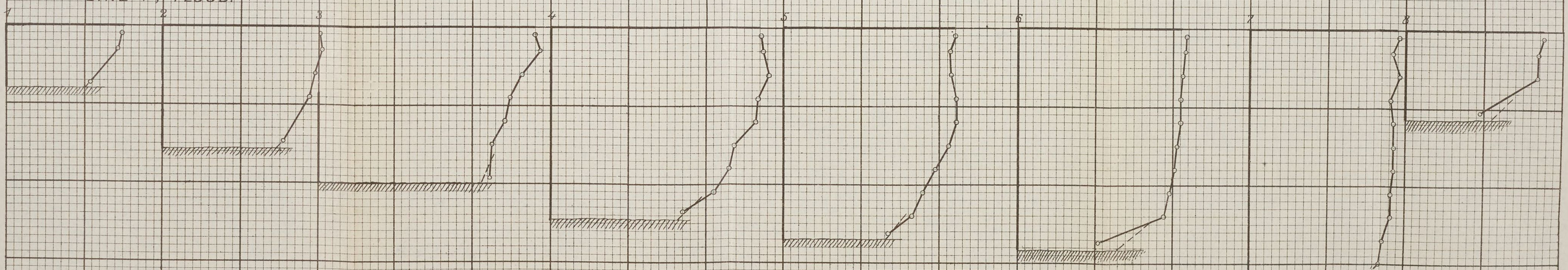
LINE D, FLOOD.



LINE F, EBB.



LINE F, FLOOD.



VELOCITIES ARE CORRECTED TO MEAN CONDITIONS OF TIDE AND OF FRESH WATER FLOW

VERT. SCALE OF DEPTHS 10 FT. TO 1 IN., HOR. SCALE OF VELOCITIES PER SECOND 1 FT. TO 1 IN.

WITH REPORT ON SURVEY OF SAVANNAH RIVER, MADE 1889 BY E.A. GIESELER, ASST. ENGR.

SHEET Nº 25.

HYDROGRAPHICAL SURVEY
OF
SAVANNAH RIVER, GEORGIA

Made 1890, under the direction of

O.M. CARTER, 1ST LT. CORPS OF ENGRS., U.S.A.

By

E. A. Gieseler, Assistant Engineer.

(GENERAL SKETCH SHOWING LOCATION OF TIDE GAUGES AND OF GAUGED CROSS SECTIONS)

Scale of Feet

1000 0 1000 2000 3000 4000

JONES ISL'D

TURTLE ISLAND

WRIGHT'S RIVER

NORTH CHANNEL

LONG ISLAND

SOUTH CHANNEL

COCKSPUR

LAZARETTO CRK

TYBEE ISLAND

*Jones Light

*Tide Gauge

LINE K

LINE H

LINE I

Dam No. 35

Dam No. 36

Dam No. 37

Dam No. 38

*Beacon

*Beacon

OYSTER BED

*Red Light

*Cockspur Light

*Tide Gauge

*Tide Gauge

Oyster Bed Training Wall

Position of Observations on Tybee Knoll

Maximum EBB Current

Buoy 7

1st Quarter, EBB.

Buoy 9

TYBEE KNOLL
EBB VELOCITIES AT DIFFERENT DEPTHS
DURING MAX. CURRENT

0 1 2 3 4 5 FT PER SEC.

SCALE OF DEPTHS

With Report on Survey of Savannah River made 1890.

SHEET Nº 26

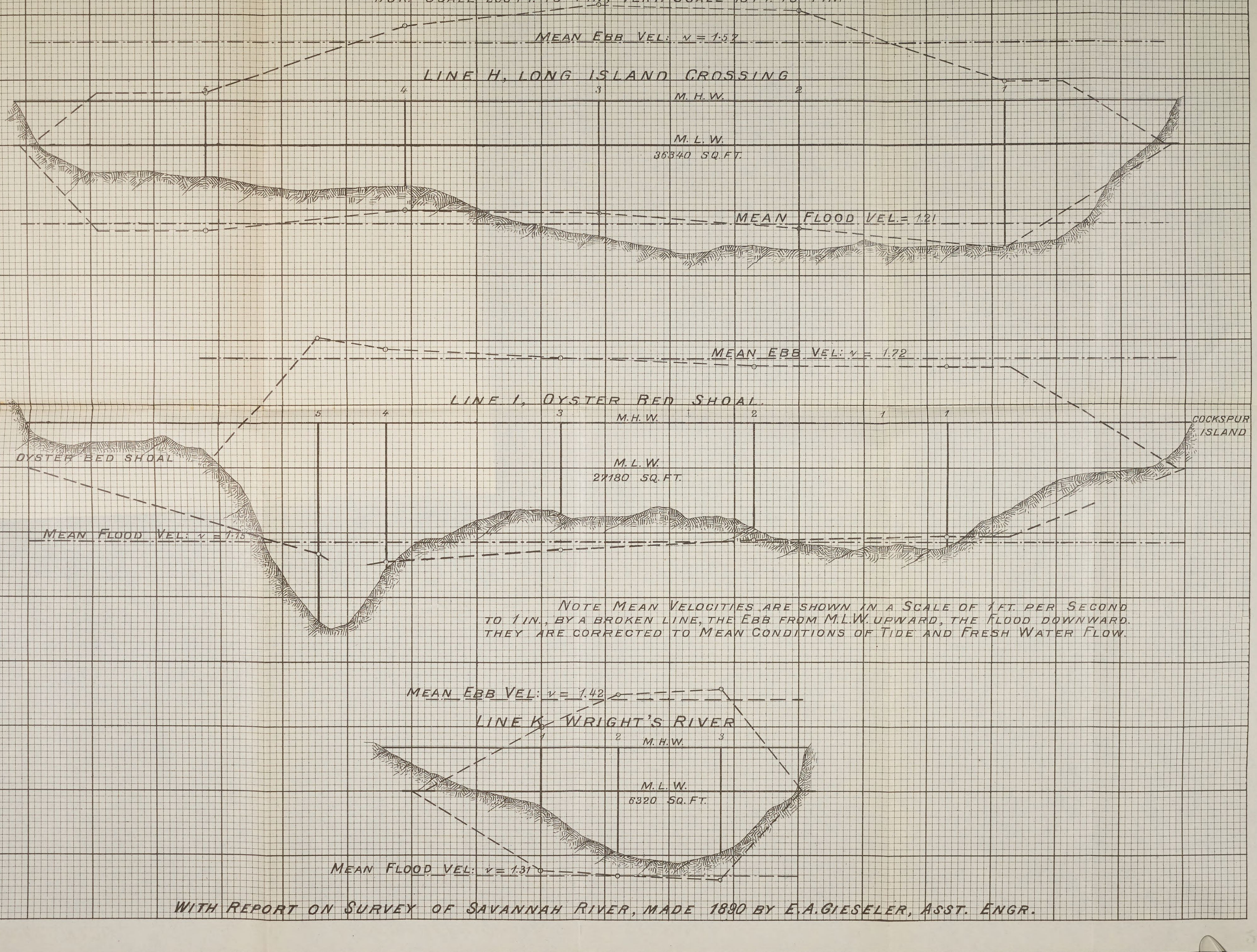
HYDROGRAPHICAL SURVEY OF SAVANNAH RIVER GA.

MADE UNDER THE DIRECTION OF

O.M. CARTER, 1ST LT. CORPS OF ENGRS. U.S.A.

GAUGED CROSSSECTIONS

HOR. SCALE 200 FT. TO 1 IN., VERT. SCALE 10 FT. TO 1 IN.



NOTE MEAN VELOCITIES ARE SHOWN IN A SCALE OF 1 FT. PER SECOND TO 1 IN., BY A BROKEN LINE, THE EBB FROM M.L.W. UPWARD, THE FLOOD DOWNWARD. THEY ARE CORRECTED TO MEAN CONDITIONS OF TIDE AND FRESH WATER FLOW.

WITH REPORT ON SURVEY OF SAVANNAH RIVER, MADE 1890 BY E.A. GIESELER, ASST. ENGR.

SHEET NOTE

A.—*Observed duration and length of flow.*

1. Line A, Ebb.

Depth of observations under surface.	Vertical 1*a*, April 13.		Vertical 11, April 12.		Vertical 2*a*, April 13.		Vertical 12, April 12.		Vertical 4, April 8.		Vertical 5, April 9.		Vertical 6, April 9.		Vertical 7, April 10.		Vertical 8, April 10.		Vertical 9, April 11.		Vertical 10, April 11.	
	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.
	h. m.	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*
1.0 foot ...	9 13	68,472	9 22	82,224	8 56	69,336	9 45	60,012	9 51	49,500	9 01	40,860	8 59	37,584	9 10	21,960	8 47	19,440	8 44	41,760	8 30	26,136
3.0 feet ...	9 14	70,632	9 25	80,064	8 58	67,032	9 57	57,636	9 59	46,800	9 07	39,312	8 50	34,452	9 07	20,448	8 41	19,008	8 48	40,644	8 29	25,128
6.0 feet ...	9 15	72,540	9 18	80,172	8 54	65,088	10 04	55,080	10 01	42,048	9 07	31,716	8 41	28,548	9 04	16,812	8 50	19,476	8 46	39,348	8 37	24,408
9.0 feet ...	9 15	72,792	9 22	80,604	8 54	63,036	9 51	50,760	9 50	34,200	9 01	24,120	.....	.....	.....	.....	8 59	19,476	8 49	38,052	8 35	23,148
12.0 feet ...	9 15	62,856	9 18	79,308	8 55	62,172	9 44	39,600	.....	.....	.....	.....	.....	.....	.....	.....	9 05	18,252	8 56	32,040	8 37	18,648
15.0 feet ...	9 12	44,280	9 16	76,860	8 57	53,100	9 41	25,560	.....	.....	.....	.....	.....	.....	.....	.....	9 15	17,338	8 54	29,628	.....	.....
18.0 feet ...	9 15	24,984	9 19	72,648	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
21.0 feet ...	.....	.....	9 22	71,460	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Means ...	9 14	59,508	9 20	77,917	8 56	63,294	9 50	48,108	9 55	43,137	9 04	34,002	8 50	33,528	9 07	19,740	8 56	18,840	8 50	36,912	8 34	23,493

2. Line A, Flood.

1.0 foot ...	3 19	5,976	3 10	7,596	.....	.....	2 47	4,104	2 41	3,708	3 16	4,068	3 18	4,068	3 25	2,880	3 48	2,952	3 33	7,416	3 48	4,104
3.0 feet ...	3 18	5,940	3 07	8,568	.....	.....	2 35	4,752	2 33	3,060	3 10	3,600	3 27	3,240	3 28	2,916	3 54	3,312	3 30	6,876	3 49	3,600
6.0 feet ...	3 17	6,372	3 14	8,748	.....	.....	2 28	3,672	2 31	2,736	3 10	3,060	3 36	2,880	3 31	1,098	3 45	3,240	3 32	6,588	3 41	3,420
9.0 feet ...	3 17	5,868	3 10	8,316	.....	.....	2 41	3,744	2 42	1,296	3 16	2,088	.....	.....	.....	.....	3 36	3,024	3 30	5,580	3 43	2,880
12.0 feet ...	3 17	5,832	3 14	7,704	.....	.....	2 48	2,916	.....	.....	.....	.....	.....	.....	.....	.....	3 30	2,376	3 22	5,040	3 41	2,448
15.0 feet ...	3 20	4,824	3 16	7,452	.....	.....	2 51	1,656	.....	.....	.....	.....	.....	.....	.....	.....	3 20	2,088	3 24	3,420	.....	.....
18.0 feet ...	3 17	1,512	3 13	7,200	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
21.0 feet ...	.....	.....	3 10	6,300	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Means ...	3 18	5,189	3 12	7,735	.....	.....	2 42	3,474	2 36	2,700	3 15	3,204	3 27	3,396	3 28	2,298	3 39	2,832	3 28	5,820	3 44	3,290

A.—*Observed duration and length of flow*—Continued.

Depth of observations under surface.	3. Line B, Ebb.														5. Line C, Ebb.							
	Vertical 1, April 16.		Vertical 2*a*, April 17.		Vertical 3, April 17.		Vertical 4, April 18.		Vertical 5, April 18.		Vertical 6, April 19.		Vertical 7, April 19.		Vertical 1, April 24.		Vertical 2, April 24.		Vertical 3, April 25.		Vertical 4, April 25.	
	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.
	h. m.	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*
1.0 foot	8 17	54,720	8 20	77,616	8 34	75,708	8 25	71,820	8 16	75,240	8 01	68,040	8 07	51,660	7 49	46,224	7 57	47,052	7 48	36,432	7 42	17,928
3.0 feet	8 19	51,012	8 20	75,240	8 30	74,088	8 28	71,892	8 19	73,908	8 01	67,860	8 01	51,984	7 49	46,548	7 53	45,072	7 48	36,432	7 41	17,748
6.0 feet	8 20	42,228	8 20	71.568	8 31	72,720	8 30	71,208	8 19	72,144	8 09	66,600	8 07	49,644	7 51	48,240	7 52	43,992	7 48	33,984	7 40	14,472
9.0 feet	8 25	35,136	8 16	61,812	8 37	57,672	8 27	68,688	8 21	69,012	8 06	62,136	8 10	46,188	7 57	48,168	7 53	43,272	7 48	25,704	.....	.....
12.0 feet	.....	.....	8 13	55,116	.....	.....	8 29	68,040	8 21	58,824	8 06	53,172	8 09	37,764	8 00	43,704	7 50	41,652	.....	.....	.....	.....
15.0 feet	.....	.....	.....	.....	.....	.....	8 28	60,372	8 14	47,772	7 59	44,748	8 19	32,940	7 57	37,944	7 52	36,612	.....	.....	.....	.....
18.0 feet	.....	.....	.....	.....	.....	.....	8 28	58,752	.....	.....	.....	.....	.....	.....	8•12	30,456	7 48	30,384	.....	.....	.....	.....
Means	8 20	45,774	8 18	68,270	8 33	70,047	8 28	67,253	8 18	66,150	8 04	60,426	8 09	45,030	7 56	43,041	7 52	41,148	7 48	33,138	7 41	16,716
	4. Line B, Flood.														6. Line C, Flood.							
1.0 foot	4 00	11,448	3 47	14,220	3 33	12,348	3 29	12,636	3 38	13,320	3 40	13,104	3 34	12,456	4 53	13,716	4 45	17,496	4 28	22,248	4 34	19,296
3.0 feet	3 58	10,116	3 47	14,112	3 37	12,096	3 26	11,880	3 35	12,816	3 38	12,600	3 40	11,952	4 53	15,552	4 49	18,828	4 28	21,672	4 35	18,396
6.0 feet	3 57	8,676	3 47	13,356	3 36	10,908	3 24	10,980	3 35	12,564	3 32	11,844	3 34	11,664	4 51	16,920	4 50	18,720	4 28	21,240	4 36	14,580
9.0 feet	3 52	5,076	3 51	12,600	3 34	9,252	3 26	10,728	3 33	12,276	3 35	11,412	3 31	10,584	4 45	16,236	4 49	18,432	4 28	16,056	.....	.....
12.0 feet	.....	.....	3 54	10,836	3 30	6,876	3 25	10,116	3 33	11.340	3 35	10,440	3 32	9,504	4 42	15,228	4 52	18,000	.....	.....	.....	.....
15.0 feet	.....	.....	.....	.....	.....	.....	3 26	9,216	3 40	8,568	3 42	7,920	3 22	7,560	4 45	13,140	4 50	15,768	.....	.....	.....	.....
18.0 feet	.....	.....	.....	.....	.....	.....	3 26	6,300	.....	.....	.....	.....	.....	.....	4 30	3,888	4 54	12,312	.....	.....	.....	.....
Means	3 56	8,829	3 49	13,025	3 34	10,296	3 26	10,265	3 36	11,814	3 37	11,220	3 32	10,620	4 46	13,526	4 50	17,079	4 28	20,304	4 35	17,424

A.—*Observed duration and length of flow*—Continued.

7. LINE D, EBB.

Depth of observations under surface.	Vertical 1, April 29.		Vertical 2, April 29.		Verticle 3, April 30.		Vertical 4, April 30.		Vertical 5, May 2.		Vertical 6, May 2.		Vertical 7, May 3.		Vertical 8, May 3.		Vertical 9, May 4.	
	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.
	h. m.	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*
1.0 foot	6 51	21,060	7 01	32,832	6 49	38,736	6 51	43,452	7 14	45,072	7 15	50,040	7 10	49,932	7 00	52,128	6 49	37,620
3.0 feet	6 36	16,920	6 52	31,032	6 45	37,008	6 54	42,516	7 06	43,740	7 06	47,448	7 03	48,888	6 57	49,824	6 46	39,888
6.0 feet	.....	.....	6 46	26,244	6 46	32,400	6 54	38,124	7 03	40,464	7 03	45,108	7 05	48,060	6 59	49,140	6 51	40,824
9.0 feet	.....	.....	6 41	23,040	6 42	23,760	6 52	29,556	7 05	35,676	6 57	41,868	7 06	44,424	6 49	48,384	6 49	38,808
12.0 feet	.....	.....	.....	.....	.....	.....	.....	.....	7 09	26,820	6 57	35,208	7 02	41,760	6 49	45,972	6 54	36,504
15.0 feet	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6 57	32,616	7 03	37,260	6 54	42,696	6 49	32,652
18.0 feet	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6 52	28,872	6 54	40,248	6 54	25,956
21.0 feet	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7 01	32,904	6 45	22,032
Means	6 43	18,990	6 51	28,287	6 45	32,976	6 53	38,412	7 07	38,354	7 02	42,048	7,03	42,742	6 56	45,162	6 50	34,285

8. LINE D, FLOOD.

1.0 foot	5 13	21,996	5 03	27,072	5 11	23,940	5 09	22,824	4 33	17,136	4 22	17,784	4 50	18,828	5 12	24,732	5 12	20,268
3.0 feet	5 21	20,304	5 12	26,388	5 15	23,256	5 06	22,428	4 41	16,956	4 31	18,504	4 57	18,864	5 17	24,336	5 15	21,060
6.0 feet	5 28	17,172	5 18	24,300	5 14	21,132	5 06	20,484	4 44	16,488	4 34	18,288	4 54	17,856	5 15	23,940	5 10	22,500
9.0 feet	.....	.....	5 23	17,784	5 18	16,560	5 08	14,364	4 42	15,120	4 40	18,000	4 54	17,640	5 25	24,552	5 12	21,708
12.0 feet	.....	.....	.....	.....	.....	.....	.....	.....	4 38	9,216	4 40	16,560	4 56	17,316	5 25	23,544	5 07	21,024
15.0 feet	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4 40	12,420	4 57	16,092	5 20	21,996	5 12	17,784
18.5 feet	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5 08	11,160	5 20	22,068	5 07	13,392
21.0 feet	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5 13	14,976	5 16	12,456
Means	5 21	19,824	5 14	23,886	5 15	21 222	5 07	20,025	4 40	14,983	4 35	16,926	4 57	16,822	5 18	22,518	5 11	18,774

A.—*Observed duration and length of flow*—Continued.

Depth of observations under surface.	9. Line E, Ebb.								10. Line E, Flood.									
	Vertical 1, May 6.		Vertical 2, May 7.		Vertical 3, May 7.		Vertical 4, May 8.		Vertical 1, May 6.		Vertical 2, May 7.		Vertical 2, May 8.		Vertical 3, May 7.		Vertical 4, May 8.	
	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length	Duration.	Length.	Duration.	Length.	Duration.	Length	Duration.	Length.	Duration.	Length.
	h. m.	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*
1.0 foot	6 07	23,616	5 32	31,032	5 35	33,192	6 03	43,020	6 01	14,580	6 35	28,908	6 35	28,800	6 32	23,580	6 40	22,392
3.0 feet	6 05	22,608	5 34	31,140	5 38	33,876	6 04	43,920	6 03	15,984	6 33	28,944	6 39	29,232	6 29	23,220	6 39	22,356
6.0 feet	5 46	19,584	5 36	30,456	5 34	33,660	6 00	41,220	6 22	17,748	6 31	28,116	6 35	27,684	6 33	25,560	6 43	22,824
9.0 feet	5 53	16,056	5 27	28,692	5 33	32,184	6 00	40,752	6 15	14,904	6 40	27,216	6 42	26,424	6 35	26,388	6 43	22,320
12.0 feet	5 59	12,888	5 24	28,404	5 32	30,636	5 50	37,908	6 09	10,008	6 43	25,488	6 53	26,388	6 33	25,344	6 53	21,636
15.0 feet	.....	.....	5 15	23,616	5 22	28,116	5 28	31,248	.....	.....	6 52	22,680	6 38	24,120	6 45	26,100	7 15	21,672
18.0 feet	.....	.....	5 09	17,100	5 22	28,256	5 15	26,280	.....	.....	6 58	20,052	6 35	20,484	6 45	23,904	7 28	21,312
21.0 feet	.....	.....	5 36	15,084	5 10	15,696	4 57	20,088	.....	...	6 31	13,824	6 20	13,932	6 57	21,600	7 46	19,440
24.0 feet	.....	.....	.....	.....	6 05	14,400	5 23	17,064	.....	.....	.....	.....	.....	.....	6 02	16,236	7 18	16,416
27.0 feet	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7 20	12,780
Means	5 58	18,950	5 27	25,690	5 33	27,224	5 40	33,500	6 10	14,645	6 40	24,403	6 37	24,633	6 34	23,548	7 04	20,313

Depth of observations under surface.	11. Line F, Ebb.															
	Vertical 1, May 10.		Vertica' 2, May 11.		Vertical 3, May 15.		Vertical 4, May 16.		Vertical 5, May 22.		Vertical 6, May 20.		Vertical 7, May 16.		Vertical 8, May 27.	
	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.
	h. m.	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*
1.0 foot	7 05	30,492	6 50	36,936	7 08	52,560	7 10	53,784	7 05	52,488	7 25	62,280	7 29	61,236	6 56	42,840
3.0 feet	6 56	27,936	6 47	36,576	7 08	49,896	7 06	53,424	7 05	52,560	7 22	60,840	7 16	60,624	6 56	40,320
6.0 feet	6 50	18,000	6 45	34,452	7 04	47,880	7 05	54,612	7 05	52,200	7 15	59,256	7 16	57,312	6 56	38,376
9.0 feet	.....	.....	6 48	33,300	7 04	46,584	7 05	55,008	7 05	50,472	7 19	56,196	7 14	57,420	6 56	33,120
12.0 feet	.....	.....	6 45	24,300	6 59	44,928	7 06	53,532	7 05	49,500	7 14	52,956	7 14	56,124	.....	.....
15.0 feet	.....	.....	.....	.....	6 55	37,692	7 09	49,572	7 05	45,036	7 16	49,860	7 11	54,000	.....	.....
18.0 feet	.....	.....	.....	.....	6 58	32,040	7 09	46,980	7 05	39,384	7 14	48,240	7 11	51,804	.....	.....
21.0 feet	.....	.....	.....	.....	.....	.....	7 09	33,372	7 05	34,164	7 08	42,948	7 06	49,500	.....	.....
24.0 feet	.....	.....	.....	.....	.....	.....	.....	.....	7 05	27,360	7 06	37,404	7 08	48,240	.....	.....
27.0 feet	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7 16	31,176	7 17	45,036	.....	.....
30.0 feet	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7 23	41,868	.....	.....
33.0 feet	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7 07	34,380	.....	.....
Means	6 57	25,476	6 47	33,113	7 02	44,511	7 07½	50,035	7 05	44,796	7 16	50,116	7 14½	51,462	6 56	38,664

A.—*Observed duration and length of flow*—Continued.

Depth of observations under surface.	12. Line F, Flood.																	
	Vertical 1, May 10.		Vertical 2, May 11.		Vertical 3, May 15.		Vertical 4, May 24.		Vertical 5, May 23.		Vertical 6, May 17.		Vertical 6, May 20		Vertical 7, May 18.		Vertical 8, May 27.	
	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.
	h. m.	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*
1.0 foot	5 29	19,512	5 30	29,160	5 15	51,048	5 10	39,780	5 22	31,968	4 38	30,636	4 43	26,964	4 31	25,704	5 19	29,016
3.0 feet	5 38	21,096	5 33	31,104	5 15	51,840	5 14	40,392	5 18	31,788	4 38	31,392	4 46	27,720	4 35	27,216	5 19	30,312
6.0 feet	5 44	14,868	5 35	31,392	5 19	48,780	5 13	38,232	5 19	31,896	4 38	31,968	4 53	28,512	4 38	28,116	5 19	30,708
9.0 feet	.....	.....	5 32	30,024	5 19	46,332	5 13	38,340	5 22	32,796	4 38	32,760	4 49	28,440	4 43	27,612	5 19	14,256
12.0 feet	.....	.....	5 35	20,736	5 24	45,900	5 17	36,858	5 21	32,472	4 38	32,616	4 54	28,620	4 42	27,252	.....	.....
15.0 feet	.....	.....	.....	.....	5 28	42,876	5 10	35,280	5 29	30,816	4 38	31,284	4 52	28,260	4 45	26,676	.....	.....
18.0 feet	.....	.....	.....	.....	5 25	38,520	5 12	31,716	5 30	28,692	4 38	30,819	4 54	27,000	4 45	27,072	.....	.....
21.0 feet	.....	.....	.....	.....	.....	.....	5 13	27,612	5 29	25,452	4 38	29,232	5 00	26,676	4 51	27,144	.....	.....
24.0 feet	.....	.....	.....	.....	.....	.....	5 13	23,760	5 28	22,824	4 38	26,208	4 02	24,156	4 49	27,036	.....	.....
27.0 feet	.....	.....	.....	.....	.....	.....	.....	.....	5 24	17,280	4 38	12,744	4 52	12,888	4 50	25,956	.....	.....
30.0 feet	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4 41	24,156	.....	.....
33.0 feet	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4 42	18,000	.....	.....
Means	5 37	18,492	5 33	28,483	5 21	46,471	5 12½	34,660	5 24	28,598	4 38	28,966	4 52	25,924	4 43	25,995	5 19	26,298

Depth of observations under surface.	13. Line G, Ebb.								14. Line G, Flood.							
	Vertical 1, May 13.		Vertical 2, May 13.		Vertical 3, May 14.		Vertical 4, May 14.		Vertical 1, May 13.		Vertical 2, May 13.		Vertical 3, May 14.		Vertical 4, May 14.	
	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.
	h. m.	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*
1.0 foot	6 46	40,860	7 16	42,336	6 28	30,024	6 06	20,484	5 38	29,304	5 29	39,420	6 03	39,060	6 25	36,432
3.0 feet	6 36	38,304	6 51	36,180	6 29	26,100	6 03	16,848	5 58	31,716	5 54	37,656	6 02	34,848	6 28	32,724
6.0 feet	6 34	31,896	6 57	27,504	6 29	19,080	5 56	13,500	6 09	27,612	5 49	32,328	6 02	29,268	6 35	27,540
9.0 feet	6 32	26,820	.....	.....	.....	.....	.....	.....	6 02	16,128	5 48	24,660	.....	.....	.....	.....
Means	6 37	34,470	7 02	35,340	6 29	25,068	6 02	16,944	5 57	26,190	5 45	33,516	6 02	34,392	6 29	32,232

B.—*Volumes of flow and mean velocities*

1. LINE A, EBB.

1	2		3	4	5	6	7	8	9	10	11
Number of vertical.	Time of change of current on date after—		a_e on date.	Observed mean length of ebb flow on date.	Ratio of mean rise and fall to fall on date.	3×4×5	4 / Duration.	Under mean tidal conditions.	Duration of mean ebb flow.	6 / 8×9	10 / 7
	H. W.	L. W.				Volume of ebb prism under mean tidal conditions.	V_m on date, feet per second.	a_e		V_m under mean tidal conditions, feet per second.	Velocity correction for tide.
	Min.	*Min.*	*Sq. feet.*	*Feet.*		*Cubic feet.*		*Sq. feet.*	*h. m.*		
1*a*	17	69	1,987	59,508	0.94	111,147,852	1.79	1,999	8 44	1.77	0.99
11	33	106	2,771	77,917	1.02	220,226,167	2.32	2,751	9 05	2.45	1.06
2*a*	36	70	1,891	63,294	0.94	112,507,617	1.97	1,917	8 26	1.93	0.98
12	−9	93	2,584	48,108	1.02	126,797,293	1.36	2,516	9 34	1.46	1.07
4	12	147	2,682	43,137	1.23	142,302,924	1.21	2,576	10 07	1.52	1.26
5	15	100	1,621	34,002	1.16	63,936,001	1.04	1,468	9 17	1.30	1.25
6	13	88	1,076	33,528	1.16	41,848,308	1.05	930	9 07	1.37	1.30
7	5	68	719	19,740	1.13	16,038,158	0.60	608	8 55	0.82	1.37
8	8	60	1,611	18,840	1.13	34,296,901	0.58	1,504	8 44	0.72	1.24
9	18	75	1,033	36,912	1.09	41,561,804	1.16	979	8 49	1.35	1.16
10	12	52	821	23,493	1.09	21,023,651	0.76	756	8 32	0.70	1.18
Sum			18,796			931,686,676		18,004			
Mean	14½	84							9 05		
Correction for fresh-water flow						−75,750,000					
Corrected ebb flow						855,936,676					

$$v = \frac{855936676}{18004 \times 32700} = 1.45$$

Velocity correction for fresh-water flow $= \frac{855936676}{931686676} = 0.92$

3. LINE B, EBB.

1	40	76	920	45,774	0.95	40,006,476	1.53	851	8 22	1.56	1.02
2*a*	49	82	1,463	68,270	0.97	96,882,640	2.28	1,394	8 19	2.32	1.02
3	40	88	994	70,047	0.97	67,537,916	2.28	941	8 34	2.33	1.02
4	42	94	1,363	67,253	0.97	88,915,864	2.21	1,319	8 38	2.17	0.98
5	46	88	1,668	66,150	0.97	107,028,054	2.21	1,618	8 28	2.17	0.98
6	45	80	1,757	60,426	1.00	106,168,482	2.08	1,699	8 21	2.08	1.00
7	37	77	1,307	45,030	1.00	58,854,210	1.53	1,244	8 26	1.56	1.02
Sum			9,472			565,393,642		9,063			
Mean	43	84							8 27		
Correction for fresh-water flow						33,462,000					
Corrected ebb flow						598.855,642					

$$v = \frac{598855642}{9063 \times 30420} = 2.17$$

Velocity correction for fresh-water flow $= \frac{598855642}{565393642} = 1.06$

(V_m), as corrected to mean tidal conditions.

2. LINE A, FLOOD.

1	2		3	4	5	6	7	8	9	10	11
Number of vertical.	Time of change of current on date after—		a_r on date.	Observed mean length of flood flow on date.	Ratio of mean rise and fall to fall on date.	3×4×5 / Volume of flood prism under tidal mean conditions.	4 / Duration. / V_m on date, feet per second.	a_r Under mean tidal conditions.	Duration of mean flood flow.	6 / 8×9 / V_m under mean tidal conditions, feet per second.	10 / 7 / Velocity correction for tide.
	L. W.	H. W.									
	Min.	*Min.*	*Sq. feet.*	*Feet.*		*Cubic feet.*		*Sq. feet.*	*h. m.*		
1*a*	69	17	2,178	5,189	0.95	10,736,560	0.44	2,146	3 41	0.38	0.86
11	106	33	3,974	7,735	1.06	32,583,223	0.67	3,904	3 20	0.69	1.03
12	93	—9	3,897	3,474	1.06	14,350,469	0.36	3,854	2 51	0.36	1.00
4	147	12	3,004	2,700	1.63	13,220,604	0.29	2,968	2 18	0.54	1.86
5	100	15	1,823	3,204	1.32	7,709,977	0.28	1,762	3 08	0.39	1.39
6	88	13	1,268	3,396	1.32	5,684,089	0.27	1,210	3 18	0.39	1.44
7	68	5	866	2,298	1.27	2,527,386	0.18	832	3 30	0.24	1.33
8	60	8	1,713	2,832	1.27	6,161,044	0.21	1,686	3 41	0.27	1.29
9	75	18	1,107	5,820	1.14	7,344.724	0.47	1,091	3 36	0.52	1.11
10	52	12	908	3,290	1.14	3,405,545	0.24	889	3 53	0.27	1.12
Sum			20,738			103,723,621		20,342			
Mean	86	12½							3 20		
Correction for fresh-water flow						36,000,000					
Corrected flood flow						139,723,621					

$$v = \frac{139723621}{20342 \times 12000} = 0.57$$

$$\text{Velocity correction for fresh-water flow} = \frac{139723621}{103723621} = 1.35$$

4. LINE B, FLOOD.

1	76	40	1,200	8,829	1.01	10,700,748	0.62	1,070	4 03	0.69	1.10
2*a*	82	49	1,723	13,025	1.05	23,564,179	0.95	1,613	4 06	0.99	1.04
3	88	40	1,194	10,296	1.05	12,908,095	0.80	1,109	3 51	0.84	1.05
4	94	42	1,556	10,265	1.05	16,770,957	0.83	1,471	3 47	0.84	1.01
5	88	46	1,904	11,814	1.05	23,618,549	0.91	1,800	3 57	0.92	1.01
6	80	45	1,997	11,220	1.08	24,198,847	0.86	1,901	4 04	0.87	1.01
7	77	37	1,567	10,620	1.08	17,972,863	0.83	1,463	3 59	0.86	1.03
Sum			11,141			129,734,238		10,437			
Mean	83⅓	42¾							3 58		
Correction for fresh-water flow						15,708,000					
Corrected flood flow						114,026,238					

$$v = \frac{114026238}{10427 \times 14280} = 0.77$$

$$\text{Velocity correction for fresh-water flow} = \frac{114026238}{129734238} = 0.88$$

B.—*Volumes of flow and mean velocities* (V_m), *as*

5. LINE C, EBB.

1	2		3	4	5	6	7	8	9	10	11
Number of vertical.	Time of change of current on date after—		a_e on date.	Observed mean length of ebb flow on date.	Ratio of mean rise and fall to fall on date.	3×4×5	4 / Duration.	a_e under mean tidal conditions.	Duration of mean ebb flow.	6 / 8×9	10 / 7
	H. W.	L. W.				Volume of ebb prism under mean tidal conditions.	V_m on date, feet per second.			V_m under mean tidal conditions, feet per second.	Velocity correction for tide.
	Min.	*Min.*	*Sq. feet.*	*Feet.*		*Cubic feet.*		*Sq. feet.*	*h. m.*		
1	45	40	1,342	43,041	0.99	57,183,412	1.51	1,298	6 58	1.76	1.17
2	48	39	2,049	41,148	0.99	83,469,129	1.45	1,999	6 54	1.68	1.16
3	41	23	1,187	33,138	0.95	37,368,066	1.18	1,165	6 45	1.32	1.12
4	41	16	749	16,716	0.95	11,894,270	0.60	717	6 38	0.69	1.15
Sum			5,327			189,914,877		5,179			
Mean	44	30							6 49		
Correction for fresh-water flow						24,540,000					
Corrected ebb flow						165,374,877					

$$v = \frac{165374877}{5179 \times 24540} = 1.30$$

$$\text{Velocity correction for fresh-water flow} = \frac{165374877}{189914877} = 0.87$$

7. LINE D, EBB.

1	50	31	582	18,990	0.98	10,831,136	0.79	617	6 44	0.72	0.92
2	50	38	1,670	28,287	0.98	46,294,504	1.15	1,715	6 51	1.09	0.95
3	39	52	1,769	32,976	1.04	60,667,926	1.36	1,845	7 16	1.26	0.93
4	34	55	1,690	38,412	1.04	67,512,931	1.55	1,768	7 24	1.43	0.92
5	35	72	2,202	38,354	1.12	94,590,169	1.50	2,263	7 40	1.51	1.01
6	39	71	2,496	42,048	1.12	117,546,025	1.66	2,550	7 35	1.69	1.02
7	34	63	3,093	42,742	1.17	154,675,177	1.68	3,093	7 33	1.81	1.10
8	38	53	2,723	45,162	1.17	143,882,067	1.81	2,723	7 18	2.01	1.11
9	41	60	1,302	34,285	1.18	52,674,103	1.39	1,348	7 22	1.47	1.06
Sum			17,527			748,674,038		17,922			
Mean	40	55							7 18		
Correction for fresh-water flow						19,710,000					
Corrected ebb flow						768,384,038					

$$v = \frac{768384038}{17922 \times 26280} = 1.63$$

$$\text{Velocity correction for fresh-water flow} = \frac{768384038}{748674038} = 1.03$$

corrected to mean tidal conditions—Continued.

6. LINE C, FLOOD.

1	2		3	4	5	6	7	8	9	10	11
Number of vertical.	Time of change of current on date after—		a_f on date.	Observed mean length of flood flow on date.	Ratio of mean rise and fall to fall on date.	3×4×5	4	a_f under mean tidal conditions.	Duration of mean flood flow.	6	10
	L. W.	H. W.				Volume of flood prism under tidal mean conditions.	Duration. V_m on date, feet per second.			8×9 V_m under mean tidal conditions, feet per second.	7 Velocity correction for tide.
	Min.	*Min.*	*Sq. feet.*	*Feet.*		*Cubic feet.*		*Sq. feet.*	*h. m.*		
1.....	40	45	1,482	13,526	1.07	21,448,719	0.79	1,468	5 27	0.74	0.94
2.....	39	48	2,210	17,079	1.07	40,386,711	0.98	2,194	5 31	0.93	0.94
3.....	23	41	1,309	20,304	1.00	26,577,936	1.26	1,343	5 40	0.97	0.77
4.....	16	41	923	17,424	1.00	16,082,352	1.06	972	5 47	0.79	0.75
Sum..	.....	.....	5,924	.....	.....	104,495,718	.....	5,977		.....	.....
Mean.	30	44	.....	.....	.....	.....	.....	.....	5 36	.....	.....
Correction for fresh-water flow						20,160,000					
Corrected flood flow						124,655,718					

$$v = \frac{124655718}{5977 \times 20160} = 1.03$$

Velocity correction for fresh-water flow $= \frac{124655718}{104495718} = 1.19$

8. LINE D, FLOOD.

1.....	31	50	780	19,824	0.90	13,916,448	1.03	780	5 41	0.87	0.84
2.....	38	50	1,923	23,886	0.90	41,339,560	1.27	1,923	5 34	1.07	0.84
3.....	52	39	2,200	21,222	0.89	41,552,676	1.12	2,164	5 09	1.04	0.93
4.....	55	34	2,135	20,025	0.89	38,050,504	1.09	2,098	5 01	1.00	0.92
5.....	72	35	2,625	14,983	1.10	43,263,413	0.89	2,634	4 45	0.96	1.08
6	71	39	2,819	16,926	1.15	54,871,553	1.03	2,880	4 50	1.09	1.06
7.....	63	34	3,410	16,822	1.23	70,556,515	0.94	3,464	4 53	1.16	1.23
8.....	53	38	3,110	22,518	1.23	86,138,105	1.18	3,176	5 07	1.47	1.25
9.....	60	41	1,654	18,774	1.24	38,504,723	1.01	1,760	5 03	1.20	1.19
Sum ..	.....	.....	20,656	.....	.....	438,193,437	.....	20,879	.....	.....	.....
Mean.	55	40	.....	.....	.....	.....	.....	.....	5 07	.....	.....
Correction for fresh-water flow						13,815,000					
Corrected flood flow						414,378,437					

$$v = \frac{414378437}{20879 \times 18420} = 1.08$$

Velocity correction for fresh-water flow $= \frac{414378437}{428193437} = 0.97$

B.—*Volumes of flow and mean velocities* (V_m), *as*

9. LINE E, EBB.

1	2		3	4	5	6	6	8	9	10	11
Number of vertical.	Time of change of current on date after—		a_e on date.	Observed mean length of ebb flow on date.	Ratio of mean rise and fall to fall on date.	3×4×5	4 / Duration.	a_e under mean tidal conditions.	Duration of mean ebb flow.	6 / 8×9	10 / 7
	H. W.	L. W.				Volume of ebb prism, under mean tidal conditions.	V_m on date, feet per second.			V_m under mean tidal conditions, feet per second.	Velocity correction for tide.
	Min.	*Min.*	*Sq. feet.*	*Feet.*		*Cubic feet.*		*Sq. feet.*	*h. m.*		
1	79	61	1,197	18,950	1.40	31,756,410	0.88	1,246	6 42	1.06	1.20
2	111	68	2,442	25,690	1.43	89,711,021	1.31	2,519	6 20	1.56	1.19
3	109	72	3,509	27,224	1.43	136,606,493	1.36	3,599	6 23	1.65	1.21
4	146	82	2,018	33,500	1.16	78,419,480	1.64	2,076	5 56	1.77	1.08
Sum			9,166			336,493,404		9,440			
Mean	111	71							6 20		
Correction for fresh-water flow						9,804,000					
Corrected ebb flow						346,297,404					

$$v = \frac{346297404}{9440 \times 22800} = 1.61$$

$$\text{Velocity correction for fresh-water flow} = \frac{346297404}{336493404} = 1.03$$

11. LINE F, EBB.

1	21	36	939	25,476	1.11	26,553,380	1.02	906	7 23	1.10	1.080
2	48	32	2,010	33,113	1.05	69,884,986	1.36	2,086	6 54	1.35	0.990
3	46	28	2,833	44,511	0.87	109,706,707	1.76	2,886	6 52	1.54	0.875
4	45	36½	3,100	50,035	0.88	136,495,480	1.95	3,164	7 01½	1.70	0.870
5	50	40½	4,298	44,796	0.98	188,682,544	1.76	4,368	7 00½	1.71	0.970
6	51	58	4,049	50,116	1.00	202,919,684	1.91	4,037	7 17	1.92	1.010
7	43	41½	5,046	51,462	0.88	228,515,982	1.97	5,120	7 08½	1.73	0.880
8	40	46	1,476	38,664	1.06	60,492,148	1.55	1,559	7 16	1.48	0.960
Sum			23,751			1,023,250,911		24,126			
Mean	43	40							7 07		
Correction for fresh-water flow						62,769,000					
Corrected ebb flow						1,086,019,911					

$$v = \frac{1086019911}{24126 \times 25620} = 1.76$$

$$\text{Velocity correction for fresh-water flow} = \frac{1086019911}{1023250911} = 1.06$$

corrected to mean tidal conditions—Continued.

10. LINE E, FLOOD.

1	2		3	4	5	6	7	8	9	10	11
Number of vertical.	Time of change of current on date, after—		a_f on date.	Observed mean length of flood flow on date.	Ratio of mean rise and fall to fall on date.	Volume of flood prism, under mean tidal conditions. $3\times4\times5$	V_m on date, feet per second. $\frac{4}{\text{Duration.}}$	a_f under mean tidal conditions.	Duration of mean flood flow.	V_m under mean tidal conditions, feet per second. $\frac{6}{8\times9}$	Velocity correction for tide. $\frac{10}{7}$
	L. W.	H. W.									
	Min.	*Min.*	*Sq. feet.*	*Feet.*		*Cubic feet.*		*Sq. feet.*	*h. m.*		
1.....	61	79	1,410	14,645	1.37	28,289,747	0.66	1,514	5 43	0.91	1.38
2.....	68	111	2,675	24,403	1.34	87,472,554	1.02	2,766	6 05	1.44	1.42
2.....	80	117	2,707	24,633	1.24	82,685,098	1.03	2,766	6 05	1.37	1.32
3.....	72	109	3,781	23,548	1.34	119,306,884	1.00	3,887	6 02	1.41	1.42
4.....	82	146	2,249	20,315	1.24	56,653,659	0.80	2,303	6 29	1.05	1.32
Sum ..	.....	.....	10,115	.....	.....	289,329,116	.....	10,470	.....	.....	.....
Mean .	72½	112½	.....	.....	.....	.....	.....	.....	6 05	.....	.....
Correction for fresh-water flow						9,417,000					
Corrected flood flow						279,912,116					

$$v=\frac{279912116}{10470\times21900}=1.22$$

$$\text{Velocity correction for fresh-water flow}=\frac{279912116}{289329116}=0.97$$

NOTE.—The mean of the two observations on vertical 2 has been used.

12. LINE F, FLOOD.

1.....	36	21	1,102	18,492	1.08	22,008,439	0.915	1,142	5 00	1.07	1.17
2.....	32	48	2,339	28,483	0.94	62,624,433	1.425	2,332	5 31	1.35	0.95
3	28	46½	3,264	46,471	0.75	113,761,008	2.413	3,132	5 33½	1.81	0.75
4.....	41	48½	3,383	34,660	0.93½	109,633,219	1.850	3,387	5 22½	1.67	0.90
5.....	40½	50	4,670	28,598	0.97½	130,213,844	1.470	4,638	5 24½	1.44	0.98
6.....	.....	43	4,376	28,966	0.92	116,614,798	1.740	4,276	5 08	1.48	0.85
6.....	58	51	4,396	25,924	1.04	118,520,380	1.485	4,276	5 08	1.50	1.01
7.....	48	42	5,488	25,995	0.95	135,527,532	1.530	5,374	5 09	1.36	0.89
8.....	46	.....	1,787	26,298	0.87	40,885,238	1.374	1,749	5 09	1.26	0.92
Sum ..	.....	.....	26,419	.....	.....	732,221,302	.....	26,030	....	.....	.....
Mean .	41	44	.....	.....	.....	.....	.....	.....	5 18	.....	.....
Correction for fresh-water flow.....						46,746,000					
Corrected flood flow						685,475,302					

$$v=\frac{685475302}{26030\times19080}=1.38$$

$$\text{Velocity correction for fresh-water flow}=\frac{685475302}{732221302}=0.94$$

NOTE.—The mean of the two observations on vertical 6 has been used.

B.—*Volumes of flow and mean velocities (V_m), as*

13. LINE G, EBB.

1	2		3	4	5	6	7	8	9	10	11
Number of vertical.	Time of change of current on date after—		a_e on date.	Observed mean length of ebb flow on date.	Ratio of mean rise and fall to fall on date.	3×4×5	4 / Duration.	a_e under mean tidal conditions..	Duration of mean ebb flow.	6 / 8×9	10 / 7
	H. W.	L. W.				Volume of ebb prism under mean tidal conditions.	V_m on date, feet per second.			V_m under mean tidal conditions, feet per second.	Velocity correction for tide.
	Min.	*Min.*	*Sq. feet.*	*Feet.*		*Cu. feet.*		*Sq. feet.*	*h. m.*		
1.....	45	— 6	610	34,470	0.90	18,924,030	1.45	638	6 25	1.28	0.89
2.....	35	9	885	35,340	0.90	28,148,310	1.40	921	6 42	1.27	0.91
3.....	32	—27	798	25,068	0.86	17,203,667	1.07	781	6 11	0.99	0.92
4.....	25	—61	647	16,944	0.86	9,427,980	0.78	628	5 44	0.73	0.93
Sum ...	.....	.....	2,940	.....	.....	73,703,987	.....	2,968	.....	.....	.....
Mean..	34	—21	.....	.....	.....	.....	.....	.....	6 15	.....	.....
Correction for fresh-water flow						3,600,000					
Corrected ebb flow						77,303,987					

$$v = \frac{77303987}{2968 \times 22500} = 1.16$$

$$\text{Velocity correction for fresh-water flow} = \frac{77303987}{73703987} = 1.05$$

corrected to mean tidal conditions—Continued.

14. LINE G, FLOOD.

1	2		3	4	5	6	7	8	9	10	11
Number of vertical.	Time of change of current on date after—		a_f on date.	Observed mean length of flood flow on date.	Ratio of mean rise and fall to fall on date.	Volume of flood prism under tidal mean conditions. $3\times4\times5$	V_m on date, feet per second. $\frac{4}{\text{Duration.}}$	a_f under mean tidal conditions.	Duration of mean flood flow.	V_m under mean tidal conditions, feet per second. 8×9	Velocity correction for tide. $\frac{10}{7}$
	L. W.	H. W.									
	Min.	*Min.*	*Sq. feet.*	*Feet.*		*Cubic feet.*		*Sq. feet.*	*h. m.*		
1.....	— 6	34	799	26, 190	0. 79	16, 531, 390	1. 22	797	6 00	0. 96	0. 79
2.....	9	37	1, 131	33, 516	0. 79	29, 946, 211	1. 62	1, 128	5 43	1. 29	0. 80
3.....	—27	32	908	34, 392	0. 74	23, 108, 673	1. 58	988	6 14	1. 04	0. 66
4.....	—61	25	769	32, 232	0. 74	18, 341, 942	1. 38	859	6 41	0. 89	0. 64
Sum..	.....	.....	3, 607	.....	.....	87, 928, 216	.....	3, 772	.....	.....	.....
Mean.	—21	32	.....	.....	.....	.....	.....	.....	6 10	.....	.....
Correction for fresh-water flow						3, 552, 000					
Corrected flood flow						84, 376, 216					

$$v=\frac{84376216}{3772\times22200}=1.01$$

$$\text{Velocity correction for fresh-water flow}=\frac{84376216}{87928216}=0.96$$

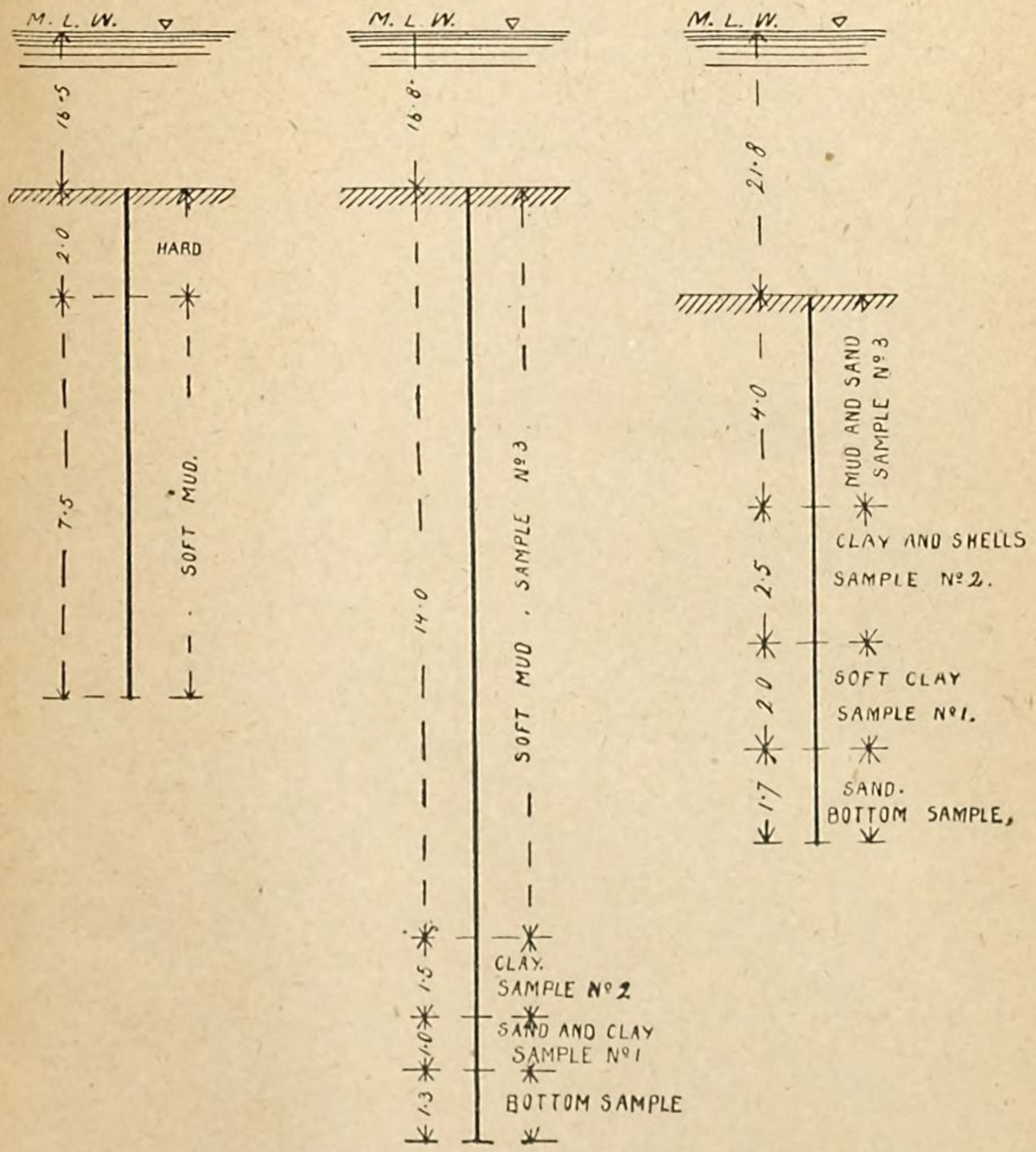
D.—*Table of comparative data for the Lower Savannah River.*

[NOTE.—The old rate for sections B to 17 refer to the year 1874, those from 21 to 36 to 1882, the rest to 1884. Mean depth $= \frac{a^e}{\text{width}}$ refers to mean surface during ebb outflow; channel depth refers to mean low water.]

No. of section.	Distance between sections.	1888.				1882, 1884 and 1874.				Location.
		Width.	a_e	Mean depth $\frac{a_e}{\text{width}}$	Channel depth.	Width.	a_e	Mean depth $\frac{a^e}{\text{width}}$	Channel depth.	
...	*Feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Feet.*	
B	.....	810	9,063	11.2	14.5	810	7,100	8.8	11.0	
3	2,500	900	10,415	11.6	11.2	875	7,340	8.6	10.5	Reed's Mill.
4	4,050	1,160	11,320	9.8	10.5	1,105	9,680	8.7	10.0	Center Marsh Island.
5	2,000	1,615	11,225	7.0	9.0	1,550	11,040	7.1	9.5	Below Marsh Island.
6	2,000	1,040	10,650	10.2	11.5	1,010	9,281	9.2	15.0	Central Railroad trestle.
7	3,250	940	11,944	12.7	21.2	885	10,141	11.5	14.0	Ogeechee Canal.
8	2,420	550	10,325	18.8	23.0	560	8,831	15.8	21.0	Above Barnard street.
9	1,500	540	10,388	19.2	20.0	540	8,679	16.1	17.0	At Abercom street.
10	1,620	800	11,675	14.6	18.0	800	9,720	12.2	13.0	Upper end Garden Shoal.
11	2,260	975	13,370	13.8	18.5	990	10,979	11.1	13.0	Lower end Garden Shoal.
12	2,060	746	13,086	17.5	21.8	746	10,035	13.5	21.0	
13	1,960	900	12,660	14.1	17.8	940	10,734	11.4	15.0	Upper end Fig Island Jetty.
14	1,700	810	10,944	13.6	16.8	.....	.....	.....	18.0	
15	1,900	745	9,208	12.4	18.5	.....	.....	.....	.....	△ Cypress.
16	1,900	1,000	12,590	12.6	15.7	.....	.....	.....	12.5	
17	1,620	934	14,335	15.3	16.8	.....	.....	.....	26.0	Lower end Fig Island Jetty.
18	3,050	1,520	28,952	19.5	27.0	.....	.....	.....	.....	Upper end Barnwell Island No. 2.
19	1,650	2,000	29,060	14.5	27.5	.....	.....	.....	.....	Center Barnwell Island No. 2.
20	3,300	1,920	20,164	10.5	16.0	.....	.....	.....	.....	Wing Dam No. 15.
21	4,900	1,370	24,820	18.1	32.5	1,370	25,900	18.9	34.5	Upper end Spirit Island.
F	3,080	1,198	24,126	20.1	31.5	1,140	27,470	24.1	38.0	
22	1,520	1,360	27,300	20.1	28.3	1,360	28,640	21.1	29.5	
										Upper Flats:
23	1,500	1,200	22,780	19.0	25.2	1,900	29,560	15.6	18.0	Wing-dams 4 and 23.
24	1,060	3,080	31,400	10.2	16.0	3,060	34,300	11.2	13.0	
25	1,340	1,140	21,240	18.6	19.2	3,620	35,390	9.8	12.0	Wing-Dams 6 and 25.
26	1,140	4,060	34,170	8.4	19.3	4,060	35,990	8.9	12.0	
27	1,160	1,310	21,890	16.7	17.0	4,000	36,920	9.2	13.0	Wing-Dams 10 and 27.
28	1,200	3,250	29,340	9.0	20.2	3,270	34,250	10.5	20.4	
29	1,130	2,830	31,570	11.2	28.5	2,780	33,970	12.2	31.0	
30	1,320	2,500	35,120	14.0	25.0	2,480	45,920	14.5	26.4	Beacon.
										Lower Flats:
31	1,940	1,520	27,240	18.0	20.5	2,480	34,680	14.0	15.3	Wing Dams 14 and 29.
32	1,230	2,740	40,710	14.9	15.0	2,740	37,350	13.6	14.4	
33	840	2,400	26,480	11.0	15.0	3,100	38,715	12.5	13.8	Wing Dam 13.
34	1,920	3,660	37,630	10.3	17.5	3,669	41,030	11.2	15.5	Center Big Gap Dam.
35	2,130	3,340	39,910	11.9	23.0	3,420	43,220	12.6	20.5	
36	2,540	3,580	43,635	12.2	18 0	3,580	46,335	12.9	19.8	
										Long Island Crossing:
37	2,280	1,520	29,720	19.5	25.0	3,220	43 670	13.6	13.6	Wing Dams 33 and 26.
38	1,700	3,400	45,770	13.5	18.0	3,280	45,740	13.9	15.5	
39	1,580	3,890	48,940	12.6	15.0	3.840	47,780	12.4	15.0	
40	1,630	1,580	28,560	11.7	19.0	4,500	48,490	10.8	14.0	Wing Dam 35.

NOTE.—Where blanks occur there is no data.

Borings taken in 1889 *on and near Tybee Knoll.*



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E.—*Observed duration and length of flow.*

1. Line H, Ebb.

Depth of observations under surface.	Vertical 1, May 16.		Vertical 2, May 16.		Vertical 3, May 16.		Vertical 4, May 16.		Vertical 5, May 16.	
	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length	Duration.	Length.
	h. m.	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*
1 foot	6 52	41,112	6 50	77,688	6 49	81,540	6 35	54,720	6 55	30,960
3 and 4 feet	6 50	37,332	6 38	70,272	6 57	77,652	6 29	50,112	6 28	20,448
6 and 7 feet	6 35	30,960	6 47	61,992	6 46	61,992	6 32	42,480	6 26	9,144
9 feet	6 23	26,064	6 16	49,860	6 55	47,484	6 29	29,988	.....	.....
12 feet	6 05	17,280	6 13	38,808	6 48	37,800	.....	.....	.....	.....
15 feet	6 01	9,972	5 50	28,116	6 43	24,840	.....	.....	.....	.....
18 feet	6 00	5,760	6 16	24,948	.....	.....	.....	.....	.....	.....
Means	6 24	24,069	6 24	50,241	6 50	55,218	6 31	44,325	6 36	20,184

2. Line H, Flood.

Depth of observations under surface.	Vertical 1, May 16.		Vertical 2, May 16.		Vertical 3, May 16.		Vertical 4, May 16.		Vertical 5, May 16.	
	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.
	h. m.	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*
1 foot	5 34	48,240	5 36	34,272	5 37	25,488	5 51	28,440	5 31	41,940
3 and 4 feet	5 36	47,520	5 48	35,640	5 29	27,072	5 57	30,240	5 58	37,908
6 and 7 feet	5 51	47,700	5 39	36,720	5 40	27,828	5 54	29,196	5 53	32,040
9 and 10 feet	6 03	47,160	6 10	37,800	5 31	28,080	5 57	18,504	6 00	25,812
12 feet	6 21	44,532	6 12	37,296	5 38	28,980	.....	.....	.....	.....
15 feet	6 22	39,960	6 36	33,012	5 43	19,908	.....	.....	.....	.....
18 feet	6 06	34,776	6 10	26,928	.....	.....	.....	.....	.....	.....
21 feet	6 26	29,232	----	.....	.....	.....	.....	.....	.....	.....
Means	6 02	42,390	6 02	34,524	5 36	26,226	5 55	26,595	5 51	34,425

Note.—The depths of observations under surface on vertical 5 were 1, 4, 7, and 10 feet; the depths on all other verticals were 1, 3, 6, 9, 12, etc., feet.

E.—*Observed duration and length of flow*—Continued.

3. LINE I, EBB.

Depth of observations under surface.	Vertical 1, May 17.		Vertical 2, May 17.		Vertical 3, May 17.		Vertical 4, May 17.		Vertical 5, May 17.	
	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.
	h. m.	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*
1 foot	7 00	69,732	6 36	60,804	6 42	62,496	6 54	78,516	6 57	68,400
3 and 4 feet	6 52	59,436	6 36	52,308	6 15	51,228	6 42	69,804	6 48	66,492
6 and 7 feet	6 54	45,648	6 36	51,516	6 17	38,628	6 26	54,396	6 35	60,660
9 and 10 feet	6 47	33,408	6 36	25,272	6 13	14,652	6 19	39,924	6 30	55,080
12 feet	6 48	23,616	6 36	11,988	.....	.....	6 08	31,320	6 18	50,220
15 feet	6 45	15,624	.....	.....	.....	.....	6 15	24,696	6 07	46,800
18 feet	.....	.....	.....	.....	.....	.....	5 58	21,780	6 12	44,280
21 feet	.....	.....	.....	.....	.....	.....	.....	.....	6 10	38,052
24 feet	.....	.....	.....	.....	.....	.....	.....	.....	5 56	32,112
27 feet	.....	.....	.....	.....	.....	.....	.....	.....	6 09	28,728
30 feet	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Means	6 51	41,244	6 36	40,378	6 22	41,751	6 23	45,777	6 22	49,082

NOTE.—The depths of observations under surface on vertical 3 were 1, 4, 7, and 10 feet; the depths on all other verticals were 1, 3, 6, 9, 12, etc., feet.

4. LINE I, FLOOD.

Depth of observations under surface.	Vertical 1, May 17.		Vertical 2, May 17.		Vertical 3, May 17.		Vertical 4, May 17.		Vertical 5, May 17.	
	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.	Duration.	Length.
	h. m.	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*
1 foot	5 07	27,216	5 31	35,424	5 25	46,044	5 13	46,728	5 10	38,088
3 and 4 feet	5 15	29,520	5 31	36,468	5 52	40,860	5 25	46,008	5 19	39,600
6 and 7 feet	5 13	31,104	5 31	36,864	5 50	34,920	5 41	45,828	5 32	40,500
9 and 10 feet	5 20	29,232	5 31	35,244	5 45	30,168	5 48	44,028	5 37	37,800
12 and 13 feet	5 16	25,560	5 31	31,572	5 54	18,648	5 59	40,320	5 49	38,844
15 feet	5 16	22,860	5 31	26,460	.....	.....	5 52	33,588	6 00	39,420
18 feet	5 22	12,816	.....	.....	.....	.....	5 43	26,388	5 55	34,120
21 feet	.....	.....	.....	.....	.....	.....	6 09	19,908	5 57	31,860
24 feet	.....	.....	.....	.....	.....	.....	.....	.....	6 11	31,680
27 feet	.....	.....	.....	.....	.....	.....	.....	.....	6 00	27,828
30 feet	.....	.....	.....	.....	.....	.....	.....	.....	5 58	21,240
Means	5 16	25,472	5 31	33,672	5 45	34,128	5 43	37,850	5 45	34,635

NOTE.—The depths of observations under surface on vertical 3 were 1, 4, 7, 10, and 13 feet; the depths on all the other verticals were 1, 3, 6, 9, 12, 15, etc., feet.

E.—*Observed duration and length of flow*—Continued.

5. LINE K, EBB.

Depth of observations under surface.	Vertical 1, May 19.		Vertical 2, May 19.		Vertical 3, May 19.	
	Duration.	Length.	Duration.	Length.	Duration.	Length.
	h. m.	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*
1 foot	5 57	27,972	6 06	38,592	5 57	37,368
3 feet	5 57	13,896	6 00	39,744	5 50	36,900
6 feet	.....	.....	6 02	35,244	5 55	36,432
9 feet	.....	.....	6 00	25,812	5 57	32,508
12 feet	.....	.....	5 58	19,872	5 43	28,224
15 feet	.....	.....	.....	.....	5 56	24,984
Means	5 57	20,934	6 01	31,853	5 53	32,736

6. LINE K, FLOOD.

1 foot	6 11	37,980	6 02	40,464	6 11	40,680
3 feet	6 11	32,220	6 08	39,528	6 18	38,196
6 feet	6 11	22,140	6 06	37,620	6 13	37,296
9 feet	.....	.....	6 08	31,392	6 11	34,956
12 feet	.....	.....	6 07	25,380	6 25	31,032
15 feet	.....	.....	6 10	21,888	6 12	25,740
Means	6 11	30,780	6 07	32,712	6 15	34,650

F.—*Volumes of flow and mean velocities*

1. Line H, Ebb.

1. Number of vertical.	2. Time of change of current on date after— H. W.	2. Time of change of current on date after— L. W.	3. a_e on date.	4. Observed mean length of ebb flow on date.	5. Ratio of mean rise and fall to fall on date.	6. 3×4×5 Volume of ebb prism, under mean tidal conditions.	7. 4/Duration. V_m on date, feet per second.	8. a_e under mean tidal conditions.	9. Duration of mean ebb flow.	10. 6/8×9 V_m under mean tidal conditions, feet per second.	11. 10/7 Velocity correction for tide.
	Min.	*Min.*	*Sq. feet.*	*Feet.*		*Cubic feet.*		*Sq. feet.*	*h. m.*		
Shore	.....	.....	2,272	12,000	0.93	25,355,520	.....	2,356	.....	.....	.....
1	71	40	9,168	24,069	0.93	205,218,071	1.04	9,324	6 16	0.98	0.94
2	74	43	11,186	50,241	0.93	521,815,084	2.18	11,354	6 16	2.04	0.94
3	64	58	10.218	55,218	0.93	524,722,297	2.24	10,404	6 41	2.10	0.94
4	55	31	6,098	44,325	0.93	251,373,280	1.89	6,284	6 23	1.74	0.92
5	47	21	4,984	20,184	0.93	93,555,262	0.85	5,182	6 27	0.78	0.92
Shore	.....	.....	832	10,000	0.93	7,737,600	.....	886	.....	.....	.....
Sum	.....	.....	44,740	.....	.....	1,629,777,114	.....	45,790	.....	.....	.....
Mean	*62	*38	.....	.....	.....	.....	.....	.....	6 25	.....	.....
Corrected for fresh-water flow						39,840,000					
Corrected flood flow						1,669,671,114					

$$v = \frac{1669617114}{45790 \times 23100} = 1.58$$

$$\text{Velocity correction for fresh-water flow} = \frac{1669617114}{1629777114} = 1.025$$

* 65 and 50 have been adopted and used in the above computations instead of these figures, in consideration of the volumes of ebb prism being so much greater on verticals 2 and 3 than on the other verticals.

3. Line I, Ebb.

Shore	.....	.....	1,760	20,600	0.94	34,080,640	.....	1,860	.....	.....	.....
1	45½	60½	6,725	41,244	0.94	260,723,946	1.67	6,850	6 55	1.53	0.92
2	60	60	7,170	40,378	0.94	272,139,645	1.70	7,320	6 40	1.55	0.91
3	55	49	6,332	41,751	0.94	248,505,292	1.82	6,492	6 34	1.62	0.89
4	65	52	5,125	45,777	0.94	220,530,697	1.99	5,200	6 27	1.83	0.92
5	64½	50½	7,336	49,082	0·94	338,461,619	2.14	7,438	6 26	1.97	0.92
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Sum	.....	.....	34,448	.....	.....	1,374,441,839	.....	35,160	.....	.....	.....
Mean	58	53	.....	.....	.....	.....	.....	.....	6 35	.....	.....
Estimated flow over oyster-bed; mean area, 700 square feet; velocity, 3.5; duration, 2h						17,640,000					
						1,392,081,839					
Correction for fresh-water flow						52,785,000					
Corrected ebb flow						1,444,866,839					

$$v = \frac{1427226839}{35160 \times 23700} = 1.71$$

$$\text{Velocity correction for fresh-water flow} = \frac{1444866839}{1392081839} = 1.04$$

(V_m), *as corrected to mean tidal conditions.*

2. LINE H, FLOOD.

1. Number of vertical.	2. Time of change of current on date, after— L. W.	2. Time of change of current on date, after— H. W.	3. a_f on date.	4. Observed mean length of flood flow on date.	5. Ratio of mean rise and fall to fall on date.	6. Volume of flood prism, under mean tidal conditions. 3×4×5	7. V_m on date, feet per second. 4 / Duration.	8. a_f under mean tidal condition.	9. Duration of mean flood flow.	10. V_m under mean tidal conditions, feet per second. 6 / 8×9	11. Velocity correction for tide. 10 / 7
	Min.	*Min.*	*Sq. feet.*	*Feet.*		*Cubic feet.*		*Sq. feet.*	*h. m.*		
Shore	.....	.....	3,115	21,200	0.80	52,830,400	.....	2,916	.....	.....	.....
1	40	71	10,733	42,390	0.80	363,977,496	1.95	10,364	6 09	1.59	0.82
2	43	74	13,034	34,524	0.80	359,988,653	1.59	12,594	6 09	1.29	0.81
3	58	64	12,084	26,226	0.80	253,531,987	1.30	11,644	5 44	1.05	0.81
4	31	55	7,964	26,595	0.80	169,442,064	1.25	7,524	6 02	1.04	0.83
5	21	41	6,971	34,425	0.80	191,981,340	1.63	6,502	5 58	1.37	0.84
Shore	.....	.....	1,374	17,200	0.80	18,906,240	.....	1,246	.....	.....	.....
Sum	.....	.....	55,275	.....	.....	1,419,658,180	.....	52,790	.....	.....	.....
Mean	38½	61	.....	.....	.....	.....	.....	.....	6 00	.....	.....
Corrected for fresh-water flow						34,461,600					
Corrected ebb flow						1,376,196,580					

$$v = \frac{1376196580}{52790 \times 21600} = 1.21$$

$$\text{Velocity correction for fresh-water flow} = \frac{1376196580}{1410658180} = 0.975$$

4. LINE I, FLOOD.

Shore	.....	.....	2,912	12,700	0.80	29,585,920	.....	2,620	.....	.....	.....
1	60½	45½	8,165	25,472	0.80	166,383,104	1.34	7,800	5 30	1.08	0.81
2	60	60	8,898	33,672	0.80	239,690,765	1.70	8,460	5 45	1.37	0.81
3	49	55	8,175	34,128	0.80	223,197,120	1.65	7,708	5 51	1.37	0.83
4	52	65	5,989	37,850	0.80	181,346,920	1.84	5,770	5 58	1.46	0.79
5	50½	64½	4,659	34,635	0.80	129,091,572	1.67	4,542	5 58	1.32	0.79
Shore	.....	.....	3,858	17,300	0.80	53,394,720	.....	3,675	.....	.....	.....
Sum	.....	.....	42,656	.....	.....	1,022,690,121	.....	40,575	.....	.....	.....
Mean	53	58	.....	.....	.....	.....	.....	.....	5 50	.....	.....
Estimated flow over oyster-bed; mean area, 1,800 square feet; velocity, 1.0; duration, 4h.						25,920,000					
						1,048,610,121					
Correction for fresh-water flow						45,360,000					
Corrected flood flow						1,003,250,121					

$$v = \frac{977330121}{40575 \times 21000} = 1.15$$

$$\text{Velocity correction for fresh-water flow} = \frac{1003250121}{1048610121} = 0.96$$

F.—*Volumes of flow and mean velocities* (V_m), *as*

5. LINE K, EBB.

1	2		3	4	5	6	7	8	9	10	11
Number of vertical.	Time of change of current on date after—		a_c on date.	Observed mean length of ebb flow on date.	Ratio of mean rise and fall to fall on date.	3×4×5	4 / Duration.	a_e under mean tidal conditions.	Duration of mean ebb flow.	6 / 8×9	10 / 7
	H. W.	L. W.				Volume of ebb prism under mean tidal conditions.	V_m on date, feet per second.			V_m under mean tidal conditions, feet per second.	Velocity correction for tide.
	Min.	*Min.*	*Sq. feet.*	*Feet.*		*Cubic feet.*		*Sq. feet.*	*h. m.*		
1	50½	22½	1,892	20,934	0.98	38,814,986	0.98	1,732	6 12	1.00	1.02
2	48	24	3,621	31,853	0.98	113,032,919	1.47	3,548	6 16	1.41	0.96
3	53	21	4,244	32,736	0.98	136,152.952	1.55	4,140	6 08	1.49	0.96
Sum	.....	.....	9,680	.....	.....	288,000,857	.....	9,420	.....	.....	.....
Mean	50½	22½	.....	.....	.....	.....	.....	.....	6 12	.....	.....
Correction for fresh-water flow						10,495,800					
Corrected ebb flow						298,496,657					

$$v = \frac{298496657}{9420 \times 22320} = 1.42$$

Velocity correction for fresh-water flow $= \frac{298496657}{288000857} = 1.04$

corrected to mean tidal conditions—Continued.

6. LINE K, FLOOD.

1	2		3	4	5	6	7	8	9	10	11
Number of vertical.	Time of change of current on date after—		a_f on date.	Observed mean length of flood flow on date.	Ratio of mean rise and fall to fall on date.	3×4×5 Volume of flood prism under tidal mean conditions.	4 / Duration. V_m on date, feet per second.	a_f under mean tidal conditions.	Duration of mean flood flow.	6 / 8×9 V_m under mean tidal conditions, feet per second.	10 / 7 Velocity correction for tide.
	L. W.	H. W.									
	Min.	*Min.*	*Sq. feet.*	*Feet.*		*Cubic feet.*		*Sq. feet.*	*h. m.*		
1	22½	50	2,340	30,780	0.84	60,501,168	1.38	2,116	6 13	1.28	0.93
2	24	48	4,170	32,712	0.84	114,583,594	1.49	3,884	6 09	1.33	0.89
3	21	53	5,028	34,650	0.84	140,344,968	1.54	4,620	6 17	1.40	0.91
Sum			11.640			321,429,730		10,620			
Mean	22½	50½							6 13		
Correction for fresh-water flow						10,907,400					
Corrected flood flow						310,522,330					

$$v = \frac{310522330}{10620 \times 22380} = 1.31$$

$$\text{Velocity correction for fresh-water flow} = \frac{310522330}{321429730} = 0.97$$

O 2.

IMPROVEMENT OF SAVANNAH RIVER BETWEEN THE CITIES OF SAVANNAH AND AUGUSTA, GEORGIA.

The Savannah River is formed by the junction of the Tugaloo and Keowee, and flows in a southeasterly direction to the sea.

A detailed description of this river is found in my report of the examination and survey of the portion above Augusta, printed as House Ex. Doc., No. 213, Fifty-first Congress, first session, and in my report of the survey of the river between Augusta and Savannah, dated June 30, 1890, and transmitted herewith.

For a special history of past work, see page 1029, Annual Report Chief of Engineers for 1888.

ORIGINAL CONDITION.

For the greater part of the year the river is navigable for steam-boats drawing from 4 to 5 feet of water, but during the low-water season there are various shoals in the upper portion of the river with low-water depths of not more than about 3 feet. The chief obstructions to navigation consist of sand and gravel bars, overhanging trees, snags, and sunken logs.

PLAN OF IMPROVEMENT.

The plan of improvement, as outlined in my report of June 30, 1890, provides for the establishment of a navigable steam-boat channel 5 feet deep at ordinary summer low water between the cities of Augusta and Savannah.

This is accomplished by—

1. Removing sand and gravel bars.
2. Regulating portions of the river, revetting caving banks, and closing incipient cut-offs.
3. Removing snags and logs from the channel and overhanging trees from the banks of the stream.

The cost of the improvement is estimated in round numbers at $332,000, provided funds are regularly and adequately supplied.

SUMMARY OF OPERATIONS PRIOR TO JULY 1, 1889.

The first appropriation ever made for the Savannah River was expended on a snag-boat built for use upon this river and the Altamaha. This boat began work upon the river on February 17, 1882, and has been employed at intervals since that date, continuous work having been impossible on account of insufficiency of funds. Irregular and inadequate appropriations have prevented the selection of the most suitable seasons for doing work. Then, too, the boat has been tied up for months at a time in a climate where decay is very rapid. As a result numerous and costly repairs have had to be made, which would not have been needed had the boat been kept in commission. The boat is now rotten and unserviceable. In all, the boat has been employed 505 days upon the river between Augusta and Savannah, removing during that time 1 sunken steam-boat, 82 piles, 980 snags, logs, and stumps, and 1,373 obstructing trees, besides a number of wrecked flats and other minor obstructions. Many of the obstacles were very large and troublesome, and their removal without a suitable snag-boat would have been impossible.

In 1883–'85 wing-dams, projecting from the South Carolina bank, were

built for the improvement of Gardner's Bar, opposite the city of Augusta, contracting the low-water way from 650 feet to 350 feet. In the same year shore protection aggregating in length 1,375 feet was put in at eight different points along the city front. Since then contracting works have been constructed at Course's Bar, Sand Bar Ferry, and Blue House Bar, situated 2, 4, and 6 miles, respectively, below the city of Augusta.

At Course's Bar 7 wing-dams have been built, 3 on the right bank and 4 on the left, reducing the low-water way from 650 to 350. At Sand Bar Ferry 5 wing-dams have been built, 1 on the right bank and 4 on the left, reducing the low-water way from 650 to 400 feet.

At Blue House Bar 7 wing-dams have been built, 4 on the right bank and 3 on the left, reducing the width of the low-water way from 650 to 400 feet. These various works have been built of brush fascines, loaded with gravel and riprap stone. In their construction there have been used a total of 13,047.61 cubic yards of brush fascines and 8,265.52 cubic yards of gravel and stone.

All work, with the exception of that done by the snag-boat, has been done by contract.

Up to July 1, 1889, the total expenditures for the work, including outstanding liabilities, amounted to $78,603.73.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

Active operations during the fiscal year consisted in the removal of snags, logs, and overhanging trees by the snag-boat *Toccoa*, and in the construction, under contract with Mr. William T. Gaynor, of works of contraction and shore protection at Blue House Bar and Sand Bar Ferry Bar.

The snag-boat *Toccoa* was rebuilt at Abbeville, Ga., under contract with Messrs. M. A. Sweeney & Bro., of Jeffersonville, Ind., and outfitted at Savannah, whence she started September 14, 1889, to begin work on the Savannah River.

Operations were carried on until November 13, between the Port Royal and Augusta Railroad Bridge and Canoe Cut, between Joe Woods's Bar and Boat Yard Landing, and between Wring Jaw Bight and Mill's Landing, improving a total length of river of 20 miles, and removing 234 snags, 10 stumps, 119 overhanging trees; 5 trees were girdled and 5 logs cut up on the bank. Operations were then suspended and the snag-boat sent to the Altamaha River.

The construction of the contracting works and shore protection at Blue House Bar was begun September 16, 1889. From the right bank to the old channel end of Dam No. 4 a new dam, No. 6, about 580 feet long, rising to about 1.5 feet above low water, was constructed. On the left bank three short spurs, Nos. 8, 9, and 10, were constructed. These spurs were carried back over the crest of the bank and widened on the face of the slope to form bank protections. Portions of old dams *a*, Nos. 2 and 4 were removed to give a new channel width of 350 feet.

The work at Sand Bar Ferry Bar was executed between October 25 and December 1, 1889. Two spur dams, designated *a* and No. 3, were constructed on the right side of the river, opposite and on line with old Dams No. 1 and No. 2, respectively. They were widened where they ascended the bank and continued beyond the crest of the bank to form shore protection as at Blue House Bar. Old Dam No. 1 was raised about 1 foot, and all the new work brought to a height of 2½ feet above low-water level. The resulting low-water channel is 350 feet in width.

There were placed in the above works a total of 4,572.0 cubic yards of fascines and 1,158.57 cubic yards of stone. There were removed from the old work at Blue House Bar 138.24 cubic yards of stone.

CONDITION OF WORK JUNE 30, 1890.

The depth of water along the city wharves at Augusta is ample. The spur dams at Gardner's Bar are in good condition, their crests being from 0.5 of a foot to 2 feet above low water. A few small breaks occur in them. The bank protection along the city front is washed out in many places. The channel across the bar is from 350 to 375 feet wide, with a minimum low water depth of 3 feet.

All the dams at Course's Bar are in good condition, the shore ends being covered with sand and mud. They rise from 0.5 of a foot to 2 feet above low water. The bar extends nearly across the river, with a depth of 4 feet, making the channel tortuous but not obstructing navigation.

At Sand Bar Ferry Bar the old shore protection and wing dam No. 3 had washed away, leaving only the bottom courses. The dams built in 1889 are in good condition, and have resulted in deepening the bar. An increased depth of 1 foot was gained even before the work was fully completed.

The new work at Blue House Bar is in good condition and has resulted in the formation of a good channel, the minimum low-water depth exceeding 4½ feet.

The freshets of 1887 and 1888 cut away the left bank of the river about 400 feet and formed a new channel behind dams *a* and *a* No. 2. The channel then rounded the end of Dam No. 4, returning to its original position; but considerable flow took place, over, through, and behind Dam No. 4. Such was the channel in May, 1889, with a depth at low water of 3½ feet. By September the channel at the end of Dam No. 4 became choked up with sand, and a new one opened up behind the dam. This new channel behind dams *a* No. 2 and No. 4 is the one which was improved in 1889.

At the Port Royal and Augusta Railroad Bridge the left bank of the river is cutting away, and the channel has a tendency to leave the draw by moving over toward the left. The main current of the river now passes to the left of the draw, making it difficult for boats to pass the draw at high water, since they have to approach at an angle with the direction of the current.

The portions of the river on which the snag-boat worked are now in a good condition; but snagging operations are much needed on the rest of the river, particularly between Buzzard's Bar and Twiggs' Bar.

A full statement of the condition of the river, as disclosed by the survey of 1889, is appended to my report of that survey.

COMMERCE AND NAVIGATION.

A detailed statement of the commerce and navigation of this river is given in my report of the Savannah River, dated June 30, 1890, and appended hereto.

MISCELLANEOUS.

The work is located in the collection district of Savannah, Ga. Savannah is the nearest port of entry. Amount of duties collected in 1889, $58,815.54. Forts Oglethorpe and Pulaski are the nearest forts, and the nearest light-houses are those upon the river below Savannah.

Since the existing project for improving the Savannah River was adopted the following appropriations and allotments have been made for the work:

By act of Congress approved—	
March 3, 1881	$15,000
August 2, 1882	25,000
July 5, 1884	15,000
August 5, 1886	15,000
August 11, 1888	21,000
Total	91,000
Received from other appropriations for use of snag-boat	2,500
Aggregate	93,500

The total expenditures to June 30, 1890, including all outstanding liabilities, were $93,480.09.

It is proposed to expend any funds which may become available during the year in the removal of obstructions, in the construction of works of shore protection, and in the improvement of shoals in the river, according to the plan contained in my report of June 30, 1890.

The sum of $75,000 can be advantageously and economically expended during the coming year.

No permanent improvement can be effected, as new obstructions caused by snags and logs form during every high-water season. They should, however, become fewer in number each year. From $3,000 to $5,000 will be required for the annual maintenance of the completed work.

Money statement.

July 1, 1889, amount available	$14,896.27
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	14,876.36
July 1, 1890, balance available	19.91
Amount appropriated by act of September 19, 1890	25,000.00
Amount available for fiscal year ending June 30, 1891	25,019.91
Amount (estimated) required for completion of existing project	307,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	75,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

Abstract of proposals for improving Savannah River, Georgia, opened at Savannah, Georgia, August 15, 1889, by First Lieut. O. M. Carter, Corps of Engineers, U. S. A.

No.	Name and address of bidders.	Price per cubic yard.						Total.
		Old stone removed.	Amount.	Riprap stone.	Amount.	Fascines.	Amount.	
1	Ronald Gillies, Brooklyn, E. D., N. Y.	$3.07	$6,000	$2.50	$2,500	$1.50	$3,000	$11,500
2	G. A. Denning, Augusta, Ga.	1.75	3,500	2.70	2,700	.80	1,600	7,800
3	Albert J. Twiggs, Augusta, Ga.	1.25	2,500	2.50	2,500	1.24	2,480	7,480
4	Wm. T. Gaynor, Fayetteville, Ky.	.50	1,000	2.00	2,000	.70	1,400	4,400

The contract (dated September 13, 1889), was awarded to William T. Gaynor, he being the lowest bidder.

SURVEY OF SAVANNAH RIVER, BETWEEN SAVANNAH AND AUGUSTA, GEORGIA, WITH PROJECT FOR IMPROVEMENT.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., June 30, 1890.

GENERAL: I have the honor to submit the following report concerning the recent survey of the Savannah River, between the cities of Savannah and Augusta, Ga., together with a project for the improvement of the same.

The Savannah River is formed by the junction of the Tugaloo and Keowee (or Seneca) rivers, and flows in a southeasterly direction to the sea at Savannah.

The survey of the river was made under my direction between May 16 and August 6, 1889, by Mr. George W. Brown, assistant engineer, whose report is appended hereto.

The basin of the Savannah River above Augusta comprises an area of about 7,294 square miles of hilly country, extending to the Blue Ridge Mountains, and having a width of from 40 to 50 miles. This portion of the river is fully described in my report on the survey of the Savannah River above Augusta, dated January 31, 1890.

The river basin below Augusta has an area of about 3,211 square miles, with an average width of 30 miles, giving a total drainage area of 10,505 square miles. In this lower portion of the valley the soil is quite sandy and permeable, forming good farming lands, the principal products of which are cotton, grain, potatoes, and garden produce. The timbered lands produce lumber and naval stores. Low swamp lands border the river for a width of from 3 to 10 miles.

The river carries considerable sediment, the amount being greatly increased during freshets. The bottom is composed of fine sand and mud. Rock occurs only in a few places, and at considerable depths, offering no obstructions to navigation. The banks vary in height, from about 25 feet above low-water level at Augusta to about 4 feet at the Cross Tides. Descending the river, the height decreases to 14 feet at McBean Creek (165); from Brigham's Landing (144) to King's Creek (115), the height is about 8 feet, and from Cohen's Bluff (101) to Purysburgh (22½), about 6 feet. The soil of the banks is sandy, sometimes mixed with clay, and is easily eroded.

The distance in a direct line from Augusta to Savannah is 107 miles. Following the river channel, the distance is 202½ miles. This distance has formerly been greatly overestimated, never, so far as is known, having been established by an actual survey until that of 1889 was made.

For the first 30 miles below Augusta the river widths are excessive, varying between 500 and 900 feet. Seven out of the nine bars on the river occur on this portion of the stream. For the remainder of the river the average low-water width is 300 feet.

The minimum low-water depths on the sand-bars of the upper portion of the river are from 3 to 4 feet. On the rest of the river, except at Brigham's Bar and Sandy Island Landing, the depth exceeds 5 feet, and averages from 8 to 10 feet.

The total fall between low water at Augusta and mean low tide at Savannah is 108 feet, giving a mean slope of 0.5333 of a foot per mile. The middle third of the river has the steepest slope, viz, 0.636 of a foot per mile, while from this part to the tidal portion the slope is about 0.5 of a foot per mile.

The river was gauged at four points, viz, Augusta, Hancock's Landing, Cohen's Bluff, and Gaffney's Landing.

The results are given in the following table:

Place.	Distance from Savannah.	Stage when gauged above low water.	Feet per second.	
			Discharge at time of gauging.	Probable low-water discharge.
	Miles.	*Feet.*		
Augusta	203.7	1.1	5,010	3,800
Hancock's Landing	152.2	1.2	5,400	3,990
Cohen's Bluff	101.1	4.4	9,460	4,085
Gaffney's Landing	38.6	4.7	10,320	4,415
Savannah	.....	.....	.....	4,485

The low-water discharge is sufficient, if properly controlled and directed, to furnish a low-water navigable channel 5 feet in depth and of ample width, with a moderate current. This depth is necessary for the safe and economical accommodation of the river traffic.

In 1888 the river at Augusta rose to a height of 38.7 feet on the city gauge, or to a height of 34 feet above low water, flooding the banks to a depth of 6 feet, and having a probable discharge of 305,000 cubic feet per second. This was the highest freshest known at Augusta, former great freshets varying from 34 to 37 feet on the gauge. Considerable fluctuations in the water-level occur every year, the river rising out of its banks and flooding the swamp lands.

The obstructions to navigation consist in general of overhanging trees, snags, sunken logs, and sand, gravel, and clay bars. At some places, due to the washing away of the banks, cut-offs are forming and will become troublesome unless their formation is arrested.

A description of the shoals encountered in descending the river is given in Mr. George W. Brown's report, appended hereto. Those places where works of improvement are now recommended are given in the following table:

Number of obstruction.	Distance from Savannah.	Name.	Character.	Recommendations.	Estimated cost of improvement.
	Miles.				
1	202.4	Gardner's Bar....	Sand-bar and caving banks.	Existing dams should be raised and additional contracting works and shore protection.	$14,000
2	201.1	Course's Bar.....	Sand-bar.....	Existing spur-dikes should be repaired and shore protection constructed.	12,450
3	200.0	Horse Creek.....	Caving bank..	Short spurs and some shore protection should be constructed to prevent further caving.	18,000
4	198.8	Sand Bar, Ferry Bar.	Sand-bar.....	Existing spur-dikes should be repaired and additional contracting works and shore protection should be constructed.	19,800
5	198.0	.....	Caving bank..	Short spurs and shore protection should be constructed to prevent further caving.	27,350
6	197.6	Blue House Bar..	Sand and clay bar.	Contracting works in the shape of spur-dikes should be constructed.	900
7	197.4	....do	Caving bank..	Spur-dikes and bank protection should be constructed.	8,850
8	194.4	Canoe Cut Bar ...	Sand-bar.....	Spur-dikes should be constructed to contract the low-water channel and shore protection is needed.	22,400
9	187.4	Twiggs' Bar.....	Sand and gravel bar.	....do.....	12,900
10	186.6	Half Guinea Bar.	Sand-bar.....	Contracting works consisting of spur-dikes, and some shore protection should be constructed.	7,300

Number of obstruction.	Distance from Savannah.	Name.	Character.	Recommendations.	Estimated cost of improvement.
11	183.2	Bailey's Point....	Caving bank	Shore protection is needed to prevent further caving.	$12,800
12	156.1	Flowery Gap Bar	Sand-bar.....	Spur-dikes should be constructed to straighten and contract the low-water channel.	3,700
13	144.0	Brigham's Bar....	....do	Contracting works consisting of spur dikes should be constructed, and piles obstructing the channel removed.	6,460
14	140.7	Little Boggy Bar.	Cut-off.....	Trees should be felled into the cut so as to close it.	75
15	134.3	Sweetwater Creek.	....do	A pile and brush dam should be built to close the cut; others in vicinity should be closed by felling trees into them.	370
16	125.6	Big Randall Point.	Caving bank..	Shore protection should be constructed to prevent caving.	3,200
17	115.4	Head of King's Creek.	Point	Point should be cased off by cutting away.	600
18	111.6	Swift Creek, and below.	Cut-off.....	Bank should be protected and trees felled into the cut.	5,000
19	107.9	.....	....do	Should be closed.....	100
20	104.5	.....	....do	....do	900
21	94.3	Swift Creek.....	....do	....do.....	200
22	93.8	.....	....do	....do.....	150
23	88.3	Thompson's Cow Fold Point.	....do	Bank should be protected and cut-off closed.	5,550
24	87.5	.....	....do	Should be closed	80
25	84.4	.....	....do	....do.....	100
26	83.5	.....	....do	Bank should be protected and cut-off closed.	5,500
27	75.2	.....	Caving bank..	Shore protection should be constructed to prevent further caving.	4,500
28	71.8	.....	Cut-offs	Should be closed	200
29	63.6	.....	....do	....do.....	200
30	58.2	.....	....do	Should be closed; banks need protection.	3,800
31	57.2	.....	....do	Should be closed; banks should be protected.	6,000
32	55.7	.....	....do.....	Should be closed	100
33	53.4	Hog Nose.....	Caving bank..	Shore protection should be constructed to prevent further caving.	10,000
34	44.0	.....	Cut-off.....	Should be closed	350
35	42.6	.....	....do	....do.....	630
36	41.5	.....	....do	....do.....	100
37	40.6	.....	....do	....do.....	150
38	33.1	.....	....do	....do.....	60
39	30.3	.....	....do	....do	250
40	17.1	Reezer Creek.....	Wreck of flatboat.	Should be removed.....	600
		Total			246,325
Removal of 5,000 overhanging trees, at $1 each.....					5,000
Removal of 7,000 snags and logs, at $5 each					35,000
Working plant.....					10,000
Total					296,325
Engineering and contingencies, 12 per cent.....					35,559
Aggregate					331,884

The above estimates are based upon the assumption that $75,000 will be annually available for the work. Should the appropriations be small in amount or irregularly made, the cost of improvement will be greatly increased.

No permanent improvement of the Savannah River can ever be effected at any reasonable cost. The soil composing the bed and banks of the river is so easily eroded that new obstructions, caused by logs, snags, and overhanging trees, form during every high-water season, and as the regimen of the river changes new shoals of gravel and sand are developed and the position and extent of sand bars now in existence, but not at present needing improvement, will be modified. To what extent this change will take place can not be foreseen, and no accurate

estimate for the improvement and maintenance of the river can now be made.

The estimate submitted herewith is for the removal of the existing obstructions to navigation. When new obstructions form, estimates for their removal can then be made.

The river, once cleared of the most troublesome and dangerous logs and snags, will require a snag-boat for perhaps only two or three months of each year, making the probable cost of maintenance of the completed work from $3,000 to $5,000 annually.

The upper portion of the river, within 16 miles of Augusta, with shoals lying close together and having a moderate slope, might be advantageously improved by resorting to slackwater navigation. The advisability of adopting this method depends on its cost as compared with that of improvement by means of contracting works and shore protection, and upon the relative efficiency of the two methods.

Five of the bars are located within 8 miles of Augusta and two others within the next 8 miles. The fall is 4.9 feet to the foot of the fifth shoal and 8.6 to the foot of the seventh. Movable dams would be required, since the discharge must be unobstructed during freshets.

To improve all of the shoals by a single dam at the foot of the seventh shoal would require a dam about 450 feet long, with a crest when raised 14 feet above the sill, and a lock 180 feet long and 50 feet wide, with a lift of 10 feet.

The low-water discharge over the dam would maintain a head of from 1.5 to 2 feet above the crest. The cost of such a dam and lock would probably be in the neighborhood of $450,000.

Two dams might be built, one at the foot of the fifth shoal and the other at the foot of the seventh. The first would be about 600 feet long, with a height of 11 and a lift of 6 feet. The latter would be about 400 feet long, with a height of 8 feet and a lift of 4 feet. These two dams would probably cost about $400,000. The two smaller dams would be preferable to the single large one, but are much more costly than the works of contraction necessary to provide a low-water channel 5 feet in depth, and after completion would require constant care and maintenance. Improvement by means of slackwater navigation is therefore not recommended.

The value of the present annual commerce on this river, as will be seen by referring to Mr. George W. Brown's report, is about $2,219,000. Of this commerce about 356,000 tons, valued at $2,140,000, were handled by the steamers, and the remainder, about 22,400 tons of logs, timber, and wood, valued at $79,000, were rafted and lightered.

The estimated cotton crop for the year 1889 of the counties bordering the river was about 120,000 bales. About 25,500 bales were raised in the country naturally tributary to the river, while only about 12,700 bales were actually carried by the river boats. An improved river and better service would undoubtedly secure a much larger proportion of the trade of the bordering counties.

The city of Augusta and the surrounding country is the region most interested in the improvement of the river, since it furnishes a highway of traffic competing with the railroads, and thus controls freight rates to the sea-coast. The value of Augusta's manufactured products in 1888 was $16,499,677, and her total trade was $63,566,000.

Since the improvement of the river was begun, the annual commerce thereon has increased by about $900,000, or at the rate of $10 increased commerce for every dollar expended by the United States in improving the river.

There are submitted herewith—

1. Report of Mr. George W. Brown, assistant engineer.
2. Index map of Savannah River between Augusta and Savannah.
3. General map of Savannah River between Augusta and Savannah.
4. Profile map of Savannah River between Augusta and Savannah.
5. Map of detail surveys of Savannah River between Augusta and Savannah.

Respectfully submitted.

O. M. CARTER,
First Lieutenant, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. GEORGE W. BROWN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., June 10, 1890.

SIR: I have the honor to submit, this day, a report upon the survey of Savannah River, Georgia, made in accordance with the following letter:

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., May 10, 1890.

SIR: Having reached Augusta, Ga., you will proceed to make a survey of the Savannah River between that point and Savannah, Ga.

From Augusta to Blue House Bar the survey will be made in detail, and the results plotted on a scale of 1 : 2400.

The existing works of improvement will be carefully examined, the soundings taken will be reduced to low water before plotting, sections of the bank will be made at points where caving is taking place, and the high and low water slopes of the river will be determined by careful leveling. Permanent bench marks will be established at points along this line for future reference. Near Augusta cross-sections of the river will be made for use in discharge measurements. If practicable these sections will be extended to the high-water mark by leveling, and permanent bench-marks established. The velocity measurements will be made by means of loaded rods, surface or double floats. Below Blue House Bar a compass and stadia survey will be made.

You will note the height and character of the river banks, the size and variety of trees and brush, the length and depth of pools and shoals, the variations in water-level at different points, the nature of the bottom, and the location, nature, and magnitude of existing obstructions to navigation, with a view to determining the means and probable cost of removing them so as to secure a depth of 5 feet at summer low-water.

The survey, which will be plotted on a scale of 1 : 14400, should show the general contour of the river banks, the location of the navigable channel, with low-water depths, the location of cut-offs, sand-bars, etc.

At shoals, where rock excavation or works of contraction may be required, detailed surveys on a scale of from 50 to 200 feet to an inch will be made and the river slope from the pool above to the pool below carefully determined.

The slope of the river from Augusta to Savannah will be determined with as much accuracy as possible, permanent bench-marks being established at intervals along the line.

Near Brigham's Bar, Cohen's Bluff, and Sisters' Ferry, the discharge of the river will be obtained.

Permanent gauge staves will be established near Cohen's Bluff and at the Charleston and Savannah Railroad Bridge, and intelligent gauge readers employed at a compensation not to exceed $10 per month. The gauges will be carefully connected with at least two good prominent and permanent bench-marks.

In view of the detailed verbal orders given you, no further written instructions are considered necessary.

You are authorized to employ such assistance and means of transportation as may be required for a vigorous prosecution of the work.

Your field maps will be kept plotted to date and the usual tri-monthly reports of operations will be submitted to this office.

Very respectfully, your obedient servant,

O. M. CARTER,
First Lieutenant, Corps of Engineers.

Mr. GEO. W. BROWN,
Assistant Engineer.

TIME OF SURVEY.

The work was begun at Augusta, May 16, 1889. The detailed survey from that city to Blue House Bar, a distance of about 5½ miles, was completed on the 8th of June, and the entire survey to Savannah on the 6th of August, 1889. From rain, high water, sickness, and other causes, delays of a total of twenty days were experienced. It was unfortunate that the needs of the river demanded a survey at a time when low water could not be expected and when the river swamps were so unhealthy.

PARTY AND METHODS.

For the first 5 miles of the work the party consisted of the assistant engineer, with a rodman, two chainmen and two laborers or boatmen. A transit line was run in general parallel to the river, beginning at the city bridge in Augusta, and ending below Blue House Bar. The angles were carefully measured and the magnetic bearings of all lines read. From the mean of the various needle readings the magnetic meridian was determined, after which the bearings of the various lines were corrected to agree with the measured angles. The line was carefully measured with a steel tape, plugs with tacks being put in at every 100 feet or oftener and at the angles. At Blue House Bar, where the lines crossed the river, its length was determined by triangulation. From this meander line one bank of the river was determined by direct measurements; the opposite shore and bank lines were run in by angles and stadia distances. From this line the wharves, bridges, jetties, etc., were accurately located. The soundings were taken upon ranges, the lines running usually about at right angles to the river, and at 50 feet to 600 feet apart. These ranges were laid off at definite angles from the meander line. Soundings at the less important places were spaced by time, checked by proportional distances to each bank. At Blue House Bar, where a large number of soundings were necessary to show the exact nature of the bottom, the soundings were accurately located by intersections in the following manner: Two flags were established on the sand-bar higher up the river, in such positions that from all points upon the area to be sounded, one of them was projected against the railroad bridge above. With each sounding on the cross ranges was recorded the point with reference to the piers and panel points of the various spans, against which one of the flags was projected. From the old bench-mark and the river gauge at Augusta, a line of check levels was run with a "wye level," to a point below Blue House Bar. The slope of the river at various stages of water was carefully determined, and one or more permanent bench-marks were established at each bar.

A house-flat, for use on the survey of the river, was built at Augusta while the survey near the city was being made. It was 30 feet long by 10 feet wide and about 2 feet deep, and was not decked over. The flat, when loaded, drew about 8 inches. On it was a house 17 feet long, 10 feet wide, and about 8 feet high, containing in two rooms accommodations for eight men. The flat was intended to drift with the current, two sweeps and a long steering-oar furnishing the guiding, and when necessary, the motive power. The accommodations were somewhat widened, without increasing the size of the flat, by placing on outriggers planks forming a passage-way fore and aft on either side of the house. During the last ten days of the work near Augusta, the flat was tied up near Blue House Bar and used for quarters.

On June 14 the general survey of the river below Blue House Bar began. The party consisted of the assistant engineer, in charge as transitman, a rodman, pilot, four boatmen, and a cook. Upon the work they were distributed as follows: With the transitman was the pilot (who did the sounding) and one boatman. A row-boat was used. The rodman had a bateau with one boatman. Two boatmen and the cook remained upon the house-flat. When detailed surveys were made the entire crew was often used. The general survey was conducted in the following manner: The transit was set up near the edge of the river at a convenient point with reference to clear and unobstructed back and fore sights of convenient lengths. A sight was taken on the rod upon a stake at the point of beginning, and the compass bearing, stadia distance and level reading carefully noted. With transit remaining fixed the rodman then went ahead, taking a turning point on a stake or fixed point near the edge of the water, in such a position that it could be readily observed from both that and the subsequent position of the transit. The transit man would then, as before, note bearing, distance, and level reading on the rod in this position, after which the transit would be moved to a position below the rodman and the back bearing, distance, and level reading taken. The rod and instrument were moved from position to position precisely as in leveling. At each position of the transit its elevation above the water level adjacent was determined by means of the sounding pole used as a level rod, and the time noted. The elevation of each turning point above the water level was determined by direct measurements and also noted. Turning points were always taken upon stakes or fixed points. In cases where it was not

possible to take a sight from or to the bank, stakes were driven in deep water upon which to hold the rod. A stake about 12 feet long was carried for this purpose. Besides the locations of turning points, there was always noted from each position of the transit the bearing of the shore, both above and below, for estimated distances, the directions of points, and of lines passing tangent to points or rounds with estimated distances, and the direction and distance to islands or other objects which would aid in procuring an accurate map. In going from one position to the next the rodman would pass the transit near the opposite shore with rod held vertically in the bateau. The width of the river would be obtained directly by stadia with no delay of the work. From the data thus obtained sketches were made in the field and the positions of the channel, and of snags, overhanging trees, or other obstructions were sketched.

In passing from one position to the next below, the transitman's boat was placed at once in the channel and kept there under the direction of the pilot, who took soundings every 50 to 500 feet, as was deemed necessary. The soundings were taken with an iron-shod pole 16 feet long, graduated to feet and tenths. In passing down the river the transitman would note the height and character of the banks; the size and kind of trees and brush; the size and depths of streams; the positions of landings, bluffs, shoals, rocks, etc. The instrument used was a Brandis transit (No. 584) with a level bulb under the telescope and a 4½-inch needle. The stadia rod used was 16 feet long and 4 inches wide. Upon the white background of the rod, every alternate tenth was black and one-tenth of a foot square. Modifications of the black squares, which would quickly catch the eye, were made to show the even feet and half feet. The tenths of the even numbered feet were on the left side of the face of the rod, and those of the odd numbered feet on the right side The figures upon the rod were large enough to be easily read at 2,000 feet. For the purpose of distinguishing the feet more clearly on the long sites the edges of the rod were painted alternately black and white in feet, the edge adjacent to the black tenths on the face being black. With the corner of the rod presented to the instrument the foot graduations would then become very prominent.

The stadia wires in the transit had not been adjusted. A slight correction was found necessary. From a series of observations made at the beginning of the work, the length of the sight in feet was found to be $102x+1$, in which x was the stadia interval in feet. Sights from 1,600 to 3,200 feet were measured by doubling the half interval, it having been found from the observations mentioned above that the intervals on either side of the middle wire were equal. With the telescope used the rod could be read to the nearest tenth with certainty at half a mile or more. Sights up to 3,200 feet were taken, when from the nature of the surroundings, positions could not be taken nearer without a great sacrifice of time. The ordinary sight was about 1,000 to 1,200 feet. At this distance the rod could be easily read to one-hundredth of a foot in elevation. No attempt was made to keep back and fore sights of equal lengths. All sights were corrected for curvature and refraction. This correction is expressed by the following formula:

$$\text{Correction} = -\left[\left(\frac{x}{5280}\right)^2 .0.5714\right] \text{feet.}$$

in which x = length of sight in feet. This is based upon a correction for curvature of —0.667 feet per mile and a mean correction for refraction of $+\frac{0.667}{7}$ feet per mile. From the formula a table was constructed, giving the mean correction to hundredths of a foot for all distances up to 3,500 feet. The instrument was kept in perfect adjustment during the entire survey,

LEVELS.

In starting from Augusta, I assumed the elevation of zero of the river gauge as given by the U. S. Signal Service to be correct. Their elevation, as determined from sources unknown to me, is 129.9325 feet above mean low tide at Charleston, S. C. On carrying the levels to Savannah, I found the mean low water as determined by the U. S. Coast Survey of 1874, at Fort Pulaski to be 26.11 feet. Upon construction of the profile of the river showing slope of water, etc., I found the levels derived to be in no cases inconsistent. For the purposes of this survey it is assumed that my levels are correct. The datum plane, to which I have referred all levels, is that of mean low water at the mouth of the Savannah River, as determined by the U. S. Coast Survey in 1874, mentioned above. All elevations determined have been corrected to this datum by substracting the constant 26.11 feet. My determination of the zero of the river gauge at Augusta is then 103.82 feet. I have endeavored to check this determination by comparison with levels given at Augusta by the various railroads centering there, but with no success. The five railroads entering the union

depot at Augusta vary among themselves by about 40 feet as to the elevation of the track at that point. None of them, however, pretends that its datum is accurately referred to the mean low water at any seaport.

The top of the rail in the union depot at Augusta, I found to be about 32.37 feet above zero of the city gauge, or at an elevation of 136.19 feet. The Central Railroad of Georgia, with the datum I have used, gives the elevation of grade in the Augusta depot as about 124.56 feet. The Port Royal and Augusta Railway gives that point as 154.00 feet above mean low water at Charleston, S. C. The Georgia Railroad gives the elevation of zero of the river gauge at Augusta as "110.30 above the Atlantic at Charleston." The Georgia Railroad also gives elevations at their crossings of the Oconee and Ocmulgee Rivers, which elevations have also been determined with reference to mean low water at Darien, Ga, by Mr. A. S. Cooper, assistant engineer, and by Mr. J. L. Van Ornum, surveyor, on their surveys of the Altamaha, Oconee, and Ocmulgee rivers in 1889. It was intended to obtain elevations between Savannah and Augusta directly, not only by the old surveys of the "Central" road, but by the recent resurveys of the Port Royal and Augusta and the Charleston and Savannah railways, through their junction at Yemassee, S. C., but the former road has neglected to furnish us with the necessary information.

Referring all levels to the same point, and assuming that the low water of the ocean is a level plane, we have the following elevations of the zero of the city gauge at Augusta:

Source.	Zero of the city gauge at Augusta.
	Feet.
U. S. Signal Service, Augusta	129.93
Port Royal and Augusta Railway (Fremont's determination, 1880)	127.07
Port Royal and Augusta Railway (G. W. Brown's determination, 1889)	121.67
Georgia Railroad	119.30
Central Railroad	92.19
Georgia Railroad, corrected by surveys on Altamaha, Oconee and Ocmulgee rivers	106.98
Survey of Savannah River, 1889	103.82

It will be seen that the elevation determined by my survey is 3.16 feet lower than that given by a line of levels running from Augusta to Milledgeville along the Georgia Railroad, a distance of about 90 miles, and down the Oconee and Altamaha Rivers to the sea, a distance of about 281 miles. How closely the levels were run on the Georgia Railroad I have no means of knowing, but if the probable error of railroad levels can be measured by any considerable portion of a variation of 40 feet in 140 feet, among five roads, we can place little confidence in their results. The errors between the Georgia Road and Darien, are, however, probably quite small, inasmuch as checks were obtained at Milledgeville, at the Savannah, Americus and Montgomery Railway crossing, at the Forks and at Doctortown; the total accumulative error being at each place less than 1 foot. A discrepancy of only 3.16 feet in a circuit of about 90 miles of railroad, nearly 500 miles of river, and about 100 miles of ocean shows what may be called excellent work. Considering the purpose for which the levels were taken, an accumulative error of 5 or 10 feet on the Savannah River would by no means vitiate the work.

The line of transit levels ran by me was checked on the upper 5 miles and on the lower 14 miles with a wye level. In the 5 miles, a difference in the two lines of less than 0.1 of a foot was found. The 14 miles ran the previous winter with a wye level were checked hastily with the transit level, and a difference of only 0.34 of a foot found. The wye determinations were in each case taken as the correct ones.

RIVER-GAUGES.

The river-gauge upon the city bridge at Augusta, which has been read for a number of years by the United States Signal Service, was tested by me and found to be at the same elevation given it by Mr. James P. Allen, United States assistant engineer, at the time of his survey in 1883. The daily readings of this gauge for the year 1889 have been kindly furnished by Sergeant D. Fisher, of the United States Signal Corps, in charge of the office at Augusta. These readings, together with the rain-fall at Augusta for the same year, are on file in this office, accompanying Sergeant Fisher's letter received February 2, 1890. For readings of the river-gauge and the rain-fall at Augusta from January 1, 1880, to December 31, 1888, see Appendix *b* of my report dated February 11, 1889. On July 20, 1889, when the survey had reached Cohen's Bluff, S. C., a gauge was established at that place and a gauge-reader employed. The gauge was set with its zero agreeing with that of the gauge previously estab-

lished there by Mr. John H. Westerfield, assistant engineer. On August 8, when the survey had reached that point, a gauge was established at Charleston Bridge (crossing of Charleston and Savannah Railway), with its zero agreeing with that of a gauge established there in January, 1889. No gauge reader could be obtained at that place. On August 14, one week after the completion of the field work, a gauge was established at Purysburg, S. C., and a gauge-reader employed. This gauge was read for this survey until January 1, 1890, when it was turned over to the survey of Savannah Harbor. The gauge-readings at Cohen's Bluff were discontinued at the end of the year. While the survey was in progress a river-gauge was kept at the house-flat. As soon as the boat stopped, for whatever length of time, a gauge was put out and read at such intervals as would give the changes in the stage of water. The amount of rise or fall in the river during the night was determined instrumentally each morning on continuing the survey. From these notes a fairly good idea of the stage of water could be carried down the river. Care was taken to err only upon the safe side. It was found after establishing the low-water "plane" from the gauge-readings of the year that in no place was the stage of water lower than we had assumed.

BENCH-MARKS.

Bench-marks were established along the river at convenient intervals. Except in a few cases the bench-marks were upon the roots and trunks of hard-wood trees. The "sap" was in all cases cut away to prevent "growing over." The heart was so manipulated as to leave a definite projecting point for the "bench," into which four nails were usually driven. The cuts were so made that no water, to cause decay, would stand in the notches. Forty benches were established and marked.

DETAILED SURVEYS.

Below Blue House Bar twelve detailed surveys were made. The usual method employed in making these surveys was as follows: The transit was set up at some point commanding the whole bar. A sight on the stadia-rod at the last turning point located the instrument. The sounding crew consisted of the rodman, as recorder, in charge of the boat, the pilot with sounding pole, a boatman to hold up the stadia rod in the boat, and two oarsmen. The rodman was instructed where to sound, and occasionally, for his guidance, ranges or flags were established on shore. The work would then proceed, the position of every second or third sounding being located by transit angle and stadia distance. The transitman would give a signal with each position located. The signal being seen by the man holding the stadia-rod, would be entered into the sounding-book opposite the depth at the position. Instead of identifying the signals by means of time, as is usual where two transits are used, I used different-colored flags for that purpose. A number of modifications of this system were employed as the case required. In a few places, where the river was narrow, a number of flags were located by compass and stadia along either shore, and soundings take from flag to flag. In all cases where time soundings were taken they were checked by proportional distances from either shore. In most cases where detailed surveys were made, bench-marks were established near the bars.

CROSS-SECTIONS OF VALLEY.

The river was gauged in four places. In but one place was it possible to give the cross-section of the valley at a height reached at by the freshets, the river being bordered upon one or both sides by from one-fourth to 4 miles of dense swamp scarcely above summer high water.

Freshet heights could be determined in but few places. The trees along the river had lost all definite marks and but few buildings were to be found low down in the swamps.

APPENDICES.

Accompanying this report are—

1. Index map, one sheet.
2. General map, nine sheets.
3. Detailed surveys and gaugings, six sheets.
4. Profile of river, one sheet.
5. Sections of river banks near Augusta, two sheets.
6. Eight original field books.

INDEX MAP.

The index map, although small, is drawn to scale. It shows all of the principal places of the river. Known limits of the river valley, above the freshet line, are shown by a line of hachures.

GENERAL MAPS.

Except as to levels taken, the general maps exhibit about all of the information collected on the survey. A dotted line shows the position of the best steam-boat channel. The soundings given are not reduced to low water, but at the beginning and ending of each day's work are notes giving the stage of the river existing at the time. In places where the bottom could not be reached with a pole 16 feet long the sounding was entered as "N. B." Positions of trees or logs in the channel are shown by "t" or "l." Marginal notes indicate particularly bad obstructions, whether of logs, snags, or overhanging trees. The traverse line of the survey is given in a light, full line. Transit points are indicated thus, △, and rod points thus, ⊙. The former are usually accompanied by numbers and the latter by letters. The numbers begin anew each day, or as often as necessary to avoid higher numbers than 10 or 12. Bench-marks are shown thus, ◎, with their descriptions given in marginal notes. Their elevations are given above mean low water at Fort Pulaski, as determined by the U. S. Coast and Geodetic Survey in 1874. All of the more important landings on the river are located and named. The larger creeks, branches and "breakovers" are shown on the maps, with estimated low-water dimensions. Systems of hachure lines are shown along river banks where they are above about 20 feet in height, each system representing a difference in level of about 20 feet. The bank heights given are estimated above the existing stage of the water. Those parts of the river or of its branches not in sight from the main channel are sketched in from the best available sources, and are not presumed to be correct, except in the lower 13 miles of the river, where the parts remote from the channel were taken from the U. S. Coast Survey chart of 1857.

Considerable confusion of local names was found, but it has been my endeavor to determine and to record the correct ones.

DETAIL MAPS.

On the detail sheets the top of the immediate banks and low-water lines are shown. The soundings on these sheets are alone reduced to low water. Bottom contours of 2 feet, 4 feet, 6 feet, 8 feet, and often of 5 feet are shown. Lines at the center and sides of the best channel 80 feet wide are also shown. Accompanying the plat in each case is a longitudinal section of the channel at the shoal. Upon these sections are shown the surface of the water at the time the soundings were taken, the assumed low-water line, a line representing the bottom of the river in the center of the channel, and another line showing the least depth in the channel 80 feet in width. In addition the 2-foot, 4-foot, 5-foot, 6-foot and 8-foot contours are projected on the section. Positions every 100 feet along the channel line are marked with letters agreeing with the same position shown on the section. The height of local low water above the sea and the description and elevation of bench-marks are also given. The detail maps between Augusta and Blue House Bar show the exact positions of all jetties constructed. When the bank and low-water lines of 1886 and 1887 differ from those of this survey they are shown in colored lines. The cutting or filling of the banks are thus shown at a glance. Changes from farther back than 1885, or at other points than between Blue House Bar and Augusta, can not be shown. Previous to the survey of 1889 no systematic survey of the Savannah River was ever made, and no detailed survey, showing bank lines, was ever made previous to that by Mr. James P. Allen, assistant engineer, in 1883 (referred to above), between Augusta and Sand Bar Ferry. Upon details Nos. 1 and 2, near Augusta, the traverse line of the survey is shown. Legends give length of line from point to point, and bearings (determined from angles between lines), with description and location of bearing trees and witness points.

A description of the gauging diagrams will be given later on.

PROFILE.

The profile shows the surface of the river at the time of the survey, the characteristic points of the river bottom, the low-water line (in red) and as near as may be the freshet line of 1888. The heights of bench-marks and the positions of gauges are shown geographically. The elevations refer, as above, to mean low-water at Fort Pulaski. It should be mentioned that the river bottom and the low-water slope for

the first 4½ miles above the City Exchange at Savannah, the point from which distances on the river are measured, have been taken from the maps and profiles of Savannah Harbor as given in the Report of the Chief of Engineers, U. S. Army, for the year 1888. From the limits of Savannah Harbor at 4½ miles to 13 miles the position of the river bottom with regard to low water was taken from the U. S. Coast Survey map of 1857. My soundings showed in a general way that no shoaling since 1857 had taken place in this part of the river. Whether the river has deepened within the last thirty-two years I could not determine with the sounding-pole used.

SECTIONS OF BANKS.

The sections of the river bank near Augusta were taken at such points as would show best the condition in which the banks were left by the freshets of 1887 and 1888.

PLANE OF LOW WATER.

Former surveys from time of that by Mr. James P. Allen, assistant engineer, referred to above, give the low water at Augusta as 4 feet 4 inches on the city gauge. The following table will show the lowest reading of the gauge during each year for the last ten years and the month in which it occurred:

Month and year.	Lowest reading during year.	Amount above assumed low water of 1883.	Month and year.	Lowest reading during year.	Amount above assumed low water of 1883.
	Feet.	*Feet.*		*Feet.*	*Feet.*
October, 1880	4.2	—0.1	September, 1885	4.7	0.4
September, 1881	4.0	—0.3	October, 1886	5.2	0.9
July, 1882	4.9	0.6	July, 1887	5.1	0.7
September, 1883	3.8	—0.5	August, 1888	5.9	1.6
October, 1884	4.1	—0.2	October, 1889	6.3	2.0

It will be seen that the low water of the river had probably been rising quite uniformly until 1887, when it came up with a wide step each year. It must be remembered that between July, 1887, and August, 1888, a very high freshet occurred, and that between August, 1888, and October, 1889, occurred the highest freshet ever known at Augusta. Supposing that 4 feet 4 inches was the ordinary lowest water, say of 1879, the third column above would give (assuming the rain-fall and evaporation constant for each year) the amount which the river bottom has lowered and risen during the time. Although the latter supposition can not hold, it seems probable that the low water has risen to a considerable extent since 1883. The lowest water of the year 1889 occurred in October. The following table shows the gauge readings at and before the time of lowest water at the three gauges on the river:

Date.	Gauge at—			Date.	Gauge at—		
	Augusta, Ga.	Cohen's Bluff, S. C.	Purysburg, S. C.		Augusta, Ga.	Cohen's Bluff, S. C.	Purysburg, S. C.
1889.	*Feet.*	*Feet.*	*Feet.*	1889.	*Feet.*	*Feet.*	*Feet.*
Sept. 23	6.9	2.8	6.6	Oct. 12	6.8	0.6	6.1
24	7.8	2.0	6.8	13	6.8	0.6	5.2
25	15.7	1.7	6.7	14	6.7	0.6	5.2
26	19.0	3.2	6.8	15	6.7	0.5	5.0
27	15.1	4.5	6.7	16	6.7	0.3	4.8
28	10.5	5.4	6.7	17	6.6	0.2	4.8
29	8.4	6.0	6.8	18	6.6	0.1	4.8
30	7.9	7.2	7.0	19	6.3	0.1	4.7
Oct. 1	7.7	7.8	7.2	20	6.3	0.0	4.8
2	7.7	8.0	7.4	21	6.3	—0.1	5.2
3	7.8	7.5	7.8	22	6.3	—0.1	5.0
4	7.6	6.3	8.2	23	6.3	—0.3	5.3
5	7.4	4.8	8.6	24	6.4	—0.4	5.2
6	7.2	3.5	8.9	25	6.5	—0.7	5.3
7	7.0	2.5	9.1	26	6.8	—0.4	Lost.
8	7.0	1.5	8.8	27	6.8	0.4	Lost.
9	6.9	1.3	8.6	28	8.7	1.2	Lost.
10	6.8	1.1	7.8	29	7.8	2.6	Lost.
11	6.8	0.8	7.1				

During the period covered by the gauge readings above, rain occurred in the section as follows:

Date.	Rain-fall at—		Date.	Rain-fall at—	
	Augusta, Ga.	Savannah, Ga.		Augusta, Ga.	Savannah, Ga.
1889.	*Inch.*	*Inch.*	1889.	*Inch.*	*Inch.*
Sept. 24	1.90	.99	Oct. 23	.10	.....
Oct. 1	.02	.01	Oct. 26	.94	.06

It will be seen that from September 24 to October 25, no rain of any importance fell in the river valley. This was a month of unusual drought all over the country. In order to be on the safe side, I have assumed low water at Augusta to be 0.5 of a foot lower than the lowest point reached during this drought, or 5.8 feet on the city gauge. While this may not be the lowest point to which the river might sink, it is very doubtful if the river in the most extreme case would go much lower. A present low water of 5.8 feet at Augusta would indicate a filling up of the river at that place of about 2 feet in seven years. (The river in September 1883, was 0.5 of a foot below assumed low water.) That the river should so fill up at that point is quite probable. Augusta is situated at the head of an alluvial valley just at the bottom of a very steep slope. From the profile submitted herewith and that accompanying my report upon the survey of Savannah River above Augusta, dated January 30, 1890, it will be seen that in the first 30 miles above the head of this valley the river has a fall of about 135 feet. Of this fall 45 feet is obtained in the lower 4½ miles, an average fall of 10 feet per mile. Below this region of excessive fall is a pool extending from 3 miles above the river gauge to 4 miles below it, with a mean slope of less than 6 inches per mile. But nearly half of the fall in this 7 miles is taken up at three or four shoals, leaving a slope to the pools of not over 0.3 of a foot per mile. The mean slope of the river between Augusta and Savannah is 0.5 of a foot per mile. In depth, the water of these pools does not differ much from the mean depth of the river for its entire length, but its width is nearly double that of the next 180 miles below. The maximum velocity of the current in these pools is about 1.6 feet per second against a mean maximum of more than 3 feet per second for the entire river. The river gauge at Augusta is located upon a pier of the new city bridge. This bridge has spans of 120 feet. At an average of less than 100 feet above this bridge is the South Carolina Railroad Bridge with spans of 180 feet. The second and fifth piers of the first bridge are nearly opposite the second and fourth piers of the railroad bridge. Piers of both bridges are of masonry upon pile foundations. They are about 8 feet wide at the water-line. Around all the piers, for a space of 10 feet or 15 feet wide on either side, large quantities of riprap stone have been thrown to protect the foundations. Nearly half the available cross-section of the river at low water has been cut off by these piers. Deep holes have been scoured out between the piers and ridges of sand deposited below. The piers of the new bridge have been in place only since about May, 1889. Until they were built about an equal number of pile-piers of the old bridge, differently spaced but upon the same line, was obstructing the free passage of the water. Below about zero of the city gauge some of the piles of the old foundations still obstruct the river. From these considerations it could reasonably be expected that at ordinary stages of water everything but the lighter particles in suspension in the torrents above would be deposited in these pools. At the times of freshets large quantities of sand would be deposited below these obstructions, particularly when (as in the freshet of 1888) such an immense body of water, probably not less than 100,000 cubic feet per second, or about one-third of the whole volume at the time was diverted from the channel toward the right, just above and just below the city. A bar would certainly form below the break-over as below an ordinary crevasse in other rivers. It is not to be expected that a material rising of the river-bed, due to the freshets of 1887 and 1888, has taken place at any great distance below Augusta.

From the diagram of comparative gauge readings during the year 1889 for the three gauges read, it will be seen that the beginning of any considerable rise at Augusta is felt two to three days later at Cohen's Bluff, and about five days later at Purysburgh. "Top high water" at Cohen's Bluff is about five days later than that at Augusta, while at Purysburgh it is ten days later. After "top high water" at Augusta a uniform stage is reached in about four days; at Cohen's Bluff in about seven days, and at Purysburgh in about ten days. To state the same thing in other words: A freshet at Augusta raising a uniform river on November 1 from 7 feet to a crest of 18 feet on the 3d, would subside to about 7 feet on the 7th. A rise would begin at Cohen's Bluff

on the 3d, would reach its maximum on the 8th, and return to a normal stage about the 15th. At Purysburgh the rise would begin on the 6th, the top would be reached on the 13th, and the normal stage attained on the 23d. The beginning of a rise has a velocity down the river of about 1½ miles per hour, its crest a velocity of about three-fourths of a mile per hour, and the normal stage following the rise a velocity of about one-half mile per hour. The mean velocity of the river has not been determined. In comparison with the velocities of floats taken at four places, and the length spent each day in drifting the house-flat used, it would seem probable that the mean current for an ordinary river runs more than 3 feet per second, or, say, 2 miles per hour. The progress of the survey down the river averaged about three-fourths of a mile per hour. The crest of a rise traveled down-stream with the same speed as the survey, a rising river with twice the speed (at the beginning), and a falling river with about two-thirds the speed (at the end). These considerations, together with the fluctuations of the river as given by the readings of the house-flat gauge, furnishes the data for determining the summer low water for all points between Augusta and Savannah, or, in other words, for determining the stage of water at which each day's soundings were taken. Carrying the stage in this way from Augusta to Cohen's Bluff would give low water there at about +0.5 on the gauge. The gauge readings previously given at that place indicate rather that low water is about —1.5 feet. From the rate of fall at other times, as shown by the diagram, and considering that the gauge at Cohen's Bluff can not be read directly below zero, it seems very improbable that the surface of the river on October 25 was lower than —0.3 or —0.4 on the gauge. (See Mr. Cohen's report for October, 1889.) It is well known that upon all of these rivers, in the absence of gauge readings, changes in water-level are always much overestimated by inexperienced persons. A height of —1 foot on the gauge at Cohen's Bluff has been taken as the most probable height of low water at that place, and the intermediate stages from Augusta down have been corrected to agree therewith. From —1 foot for low water at Cohen's Bluff, prediction would give low water at mean tide for Purysburgh at about 3 feet on the gauge. While the gauge readings are somewhat erratic at that place, it would seem probable that summer low water for the mean tide would be at about 4 feet, and for low tide at about 3 feet. The rise of tide for summer low water at Purysburgh is supposed to be about 2 feet. To be on the safe side, it has been assumed that the low-tide reading at summer low water is 2.5 feet, and the mean tide 4 feet. The predicted stages from Cohen's Bluff to Purysburgh and from Purysburgh to Cross Tides have been corrected therewith. From 4½ miles above Savannah to the city the low-water line has been taken from former determinations in Savannah Harbor.

GAUGINGS.

On this survey the river was gauged at three places: On June 27, at Hancock's Landing (152.2 miles); on July 20, at Cohen's Bluff (101.1 miles), and on July 30, at Gaffney's Landing (38.6 miles). Subsequent to the freshet of 1888 I gauged the river at Augusta (203.2 miles) at 10.4 feet and at 24.3 feet on the city gauge. It was intended to gauge the river above Blue House Bar during the survey of that part of the river in May and June, 1889, but we were prevented from doing so by sudden rises in the river. The river was, however, gauged at Augusta (at 203.7 miles) at a low stage on the 31st of October, 1889. (See my report on the survey of Savannah River above Augusta, dated January 31, 1890.) The methods employed in ganging the river were, in general, as follows: A suitable place having been chosen, a base line 200 feet in length, as nearly parallel as possible to the main current, was laid off along the river bank. From either end of the base-line sections at right angles to it were marked out and soundings on these lines carefully taken. The position of every second or third sounding was located from shore by means of transit and stadia. The velocities of the stream were determined by means of loaded rod floats. The floats were dropped from a boat a short distance above the upper section ranges. The position of crossing the upper range was determined by a transit on the range at the upper end of the base line with a stadia rod in the boat closely following the path of the float. The position of crossing the lower range 200 feet below was determined by an angle, taken with the transit, between the base line and the float. The time of crossing each range was taken to the nearest second. Floats were run across these sections every 10 to 25 feet, depending upon the cross-section of the river bottom. The height of the river during the sounding of the sections and the ganging were taken from a temporary gauge referred in each case to one or two permanent bench-marks. A plat is made to proper scale showing the ranges and so much of the river as is necessary. The path of each float is shown upon the plat. Cross-sections of the river-bed are shown at both upper and lower ranges. A third and mean cross-section is constructed on a line midway between the ranges, with depths of water at points where each float crosses this intermediate line, equal to a mean between the depths

of the water under the points where the float intersects each of the ranges. In general, the longest floats which would not drag the bottom were used. The mean velocity for any vertical is determined from the rod velocity by the following formula:

$V^m = V_r [1 - 0.116 (\sqrt{D} - x)]$ in which

V^m = mean velocity for the vertical

V^r = velocity of the rod

$$D = \frac{\text{Distance between bottom of rod and bottom of river}}{\text{depth of river}}$$

and x is a function of $\frac{l}{d}$, l being length of the rod and d the depth of the water.

For the various values of $\frac{l}{d}$ the following values of x are used:

When $\frac{l}{d}$ =	Use x equal to
0.9	+.10
0.8	+.05
0.7	.00
0.6	—.05
0.5	—.10

When $\frac{l}{d}$ = + 0.9 or more, the formula is that given by Mr. James B. Francis, in the "Lowell Hydraulic Experiments." These corrections to the formula given by Mr. Francis were deduced by myself from a large number of observations made at the time of gauging the river at Augusta, in 1888, mentioned above. From the mean velocities and the mean section the discharge is determined. When the river bottom was not reasonably regular or when greater accuracy was desired, as in the low-water gauging at Augusta, a middle section was also sounded out and a mean section determined in the manner mentioned above, double value being given to the middle section. For further details of the work, see gauging diagrams on detail sheets Nos. 4, 5, and 6 accompanying this report and diagram of gaugings accompanying my report on the survey of Savannah River above Augusta, dated January 31, 1890. From the gaugings at Augusta at 10.4 feet and 24.3 feet and from velocities taken during the freshet of 1888 a diagram was constructed giving discharges of the river at Augusta for various readings of the gauge from 8 to 40 feet. For diagram, see my report dated February 11, 1889. From the gauging at Augusta on October 31, 1889, above diagram was corrected for lower readings of the gauge. (See my report above referred to, dated January 31, 1890.) From the above diagram the following discharges are obtained at Augusta, for various readings of the gauge:

Height of water on gauge.	Discharge of river, cubic feet per second.	Height of water on gauge.	Discharge of river, cubic feet per second.
Feet.		*Feet.*	
5.0	3,000	15.0	22,700
6.0	4,000	16.0	25,500
7.0	5,210	17.0	28,700
8.0	6,600	18.0	32,100
9.0	8,400	19.0	35,500
10.0	10,400	20.0	39,000
11.0	12,600	25.0	60,000
12.0	14,900	30.0	89,000
13.0	17,300	35.0	155,000
14.0	20,000	40.0	370,000

It should be noted that these discharges apply to the Savannah River since the freshet of September, 1888, and not before.

The following table shows in the first, second, fifth, and sixth columns the results

of the four gaugings of the river in 1889. The third, fourth, seventh, and following columns give the areas drained and deductions from the gaugings.

Place or section gauged.	Distance from Savannah.	Total area of river valley above each section.	Area of river valley tributary to each section and not tributary to the section above.	Stage of water at each section above local low water.	Discharge of river at time of gauging, cubic feet per second.	Stage of water at Augusta corresponding with stage at section gauged.	Discharge at Augusta in cubic feet per second, corresponding with stage of water given in column 7.	Additional discharge of river in cubic feet per second, derived from valley between section gauged and Augusta, corresponding with stage of water in column 7.	Probable flow in cubic feet per second per square mile for area given in column No. 4 at low water.	Probable increase in discharge at low water, due to area given in column 4 and flow given in column 10, cubic feet per second.	Probable low-water discharge at each section gauged and at Savannah, Ga., cubic feet per second.
1	2	3	4	5	6	7	8	9	10	11	12
	Miles.	*Sq. m.*	*Sq. m.*								
Augusta	203.7	7,294	.....	1.1	5,010	.....	.....	.....	.....	.....	3,800
Hancock's Landing.....	152.2	8,246	952	1.2	5,400	1.1	5,010	390	0.20	190	3,990
Cohen's Bluff..	101.1	8,720	474	4.4	9,460	3.4	8,800	660	0.20	95	4,085
Gaffney's Landing.....	38.6	10,038	1,318	4.7	10,320	3.5	9,000	1,320	0.25	330	4,415
Savannah	0.0	10,505	467	.....	.....	.....	.....	.....	0.15	70	4,485

Deductions from the observed discharge at each section, gauged below Augusta to the low-water discharge, are made with a considerable degree of uncertainty. But knowing the additional area of the river valley at each succeeding section below Augusta, the low-water flow from similar territory and the low-water discharge of the river at Augusta, we may approximate very closely to the low-water discharge at each section gauged and at Savannah. From gaugings of the Savannah River above Augusta (see my report upon the survey of that river, dated January 31, 1890,) it was shown that at low water (a stage corresponding exactly with the low water assumed in this report) the flow in cubic feet per second per square mile was 0.68 cubic feet for the headwaters, including all the mountainous portion of the watershed; 0.18 cubic feet for Little River of Georgia; 0.25 cubic feet for Little River of South Carolina, and 0.23 cubic feet for the remaining portions of the valley above Augusta. What I have called "low water" in this report is a condition which would only exist as the result of a summer's drought of at least a month's duration. The lowest portions of the river valley would then be 6 feet or 8 feet above the water in the river, and dry. The only water which would reach the river from these areas would flow from only the larger springs, which experience teaches us are not so frequently met with here as upon higher ground. We could not expect more than 0.20 cubic feet per second to reach the river from each square mile of the valley below Augusta, except perhaps for that area drained by Brier Creek, much of which is higher ground. If we assume, as we have done in the above table, the flow per square mile from the valley between Augusta and Cohen's Bluff to be 0.20 cubic feet per second; between Cohen's Bluff and Gaffney's Landing to be 0.25 cubic feet per second, and between Gaffney's Landing and Savannah to be 0.15 cubic feet per second, we can not be very much in error either way. It is difficult to predict, from the stage of water at each section gauged, what stage would exist at Augusta in a river neither rising nor falling. The figures given in column 7, and consequently in columns 8 and 9, are therefore uncertain. It is known, however, that the gaugings made at Augusta and at Hancock's Landing were at about the same stage of the river. When we consider the stage of the river at which these two gaugings were made, the results agree within 100 cubic feet per second.

At no places where the gaugings were made were the sections extended to the high water mark of the freshet of 1888. At the three places below Augusta no freshet marks remained, and in each case was the river valley, of unknown extent, on one or both sides at an elevation of from 8 to 15 feet less than the probable freshet height. Even were the valleys of known extent, they were so covered with trees and bushes

as to render even the most careful determination of freshet discharges mere guess work. At Augusta the cross-section of the valley was measured in 1888 and estimates of flood discharges made. (See my report dated February 11, 1889.)

FRESHETS.

About three months after the "Big Freshet" on the Savannah River (the highest freshet known at Augusta) I determined and recorded the heights reached by the water at a large number of places between a point 20 miles above Augusta and another 4 miles below. By midsummer of 1889 nearly all freshet marks had disappeared. Upon buildings only did the marks remain. There were originally few buildings in the river swamps but many of these were washed away. Below Sand Bar Ferry the freshet heights for 1888 were determined at the following places: Near Twiggs' Bar at Silver Bluff, Johnson's Landing, Burton's Ferry, Matthew's Bluff, Hudson's Ferry, and Purysburg. Below the last-named place freshet determinations had been made in 1888. From these elevations a freshet line has been drawn upon the profile of the river, which represents as nearly as may be done without additional data the freshet slope for the river at the freshet of 1888. The following table shows the depth to which the water spread over the valley along the river banks at this freshet.

Place.	From Savannah.	Depth of water above river banks.	Place.	From Savannah.	Depth of water above river banks.
	Miles.	*Feet.*		*Miles.*	*Feet.*
Augusta	201	6	Thompson's Cut	84	15
Twiggs's Bar	187	9	Porter's Landing	62	16
Hollow Creek	176	12	Sisters' Ferry, Ga	47	16
Haynes's Cut	158	16	Gaffney's Landing	39	13
"Obstructions"	137	16	Beck's Ferry	27	8
Johnson's Landing	122	15	Charleston Bridge	14	8
Saxon's Landing	104	12	Cross Tides	4	6

At Augusta a record is kept of the highest freshets, extending back fifty years. The following is a list obtained from those records:

(Heights refer to present river gauge at Augusta.)

Year.	Maximum height of freshet.	Year.	Maximum height of freshet.
	Feet.		*Feet.*
1840	37.5	1865	36.4
1852	36.8	1887	34.5
1864	34	1888	38.7

At Petersburgh, Ga., about 56 miles above Augusta, the freshet of 1887 was 1 foot higher than that of 1888. At Augusta, that of 1887 was lower by about 4 feet; while at Charleston Bridge that of 1887 was lower by only 1½ feet. The apparent discrepancy between Augusta and Charleston Bridge for the freshet heights of 1887 and 1888 was no doubt caused by a second rise at Augusta, ten days after the freshet of 1887, to within 1½ feet of the height of that freshet. The following table shows the rain-

fall at Augusta, and the heights of the river each day at 8 a. m. at and previous to the freshets of 1887 and 1888:

Freshet of 1887.			Freshet of 1888.		
Date.	Rainfall.	Height of river.	Date.	Rainfall.	Height of river.
	Inches.	*Feet.*		*Inches.*	*Feet.*
July 19	0.02	5.2	Aug. 28	.....	6.4
20	0.01	5.2	29	0.38	6.5
21	0.90	5.4	30	0.05	8.6
22	0.01	5.8	31	0.23	8.8
23	0.11	5.7	Sept. 1	0.28	14.8
24	.....	5.7	2	0.28	18.4
25	.....	6.5	3	0.95	17.7
26	0.05	7.5	4	0.06	21
27	0.04	6.8	5	0.17	16
28	.....	6	6	0.07	16.5
29	4.18	14	7	0.17	23.9
30	1.19	32.3	8	.....	28.3
31	.....	34.5	9	0.60	23.5
Aug. 1	0.63	32	10	3.11	34.7
2	0.08	28.1	11	.....	38.1
3	0.17	31.7	12	.....	33.9
4	.....	32.1	13	.....	23.2
5	.....	23.9			
6	0.10	19.2			
7	1.38	20.8			
8	0.96	24.2			
9	1.44	30.8			
10	.....	33			
11	.....	24			
Maximum height of freshet July 31...		34.5	Maximum height of freshet Sept. 11...		38.7
Probable discharge of river at this height= 155,000 cubic feet per second.			Probable discharge of river at this height= 305,000 cubic feet per second.		

The following table shows total rainfall at Augusta for the months of July and September for the last ten years:

Year.	Rainfall for—		Year.	Rainfall for—	
	July.	September.		July.	September.
	Inches.	*Inches.*		*Inches.*	*Inches.*
1880	5.98	0.83	1886	7.87	0.65
1881	3.46	7.01	1887	8 22	0.81
1882	3.62	3.22	1888	1.74	7.82
1883	1,88	1.22	1889	10.41	3
1884	3.18	4.23			
1885	3.57	2.78	Means	4.99	3.16

It will be seen that the rainfall for one day previous to the highest river at the freshets of July, 1887, and September, 1888, was about equal to the mean rainfall for those months for the last ten years, the total rainfall for those two months of 1887 and 1888 respectively being about twice the mean rainfall for those months during the ten years.

On September 17, 1881, a rainfall of 4.94 inches at Augusta caused a rise to only about 12 feet on the gauge. On March 23, 1882, a rainfall of 3.26 inches at Augusta caused a rise to about 15.7 feet. On July 26 a rainfall of 3.83 inches at Augusta caused a rise to only about 12 feet. It will be seen that excessive rainfalls in the river valley only cause freshets when the valley is previously thoroughly saturated with water.

DISTANCES.

From the general maps of the river prepared for this survey I have carefully measured the channel line, in all cases taking the longest line necessarily traveled by boats. I find the distance from the Savannah Exchange to Augusta wharves to be 202½ miles. This distance is, however, by the way of King Creek, leaving out Herschman's Lake. While boats still use the old river up as far as Herschman's

Lake at good stages of water and avoid King Creek entirely on high freshets, at low stages of the river they are shut out of the old river entirely. Previous authorities give the distance from Savannah to Augusta (doubtless by the way of Herschman's Lake) as 248, 272, 276, and 305 miles. As far as I have been able to determine, no survey which could give even approximately the length of the river has ever been made above the limits of the U. S. Coast Survey, as shown on their map of Savannah Harbor for 1857. As a check upon the general accuracy of the maps presented herewith, I have carefully measured an air line joining the cities of Augusta and Savannah and find it to be 107 miles. The distance scaled from the largest State and United States maps available varies from 100 miles to 110 miles, with a mean of 106 miles. No better check could be desired.

The following table shows not only the distances above Savannah of all the principal landings on the river (with a few other prominent points), but the elevation of low water at those places above the mean low water of the U. S. Coast Survey of 1874, at Fort Pulaski, Ga.

Table of distances and elevations, Savannah River.

Place.	Distance from Savannah, Ga.	Elevation of low water.	Place.	Distance from Savannah, Ga.	Elevation of low water.
	Miles.	*Feet.*		*Miles.*	*Feet.*
Savannah, Ga	.....	1.7	King Creek Landing, S. C	114.7	59.7
Cross Tides, Ga	4.2	3	Burton Ferry, Ga	116.3	60.7
Drakies Landing, Ga	9.4	3.4	Johnson's Landing, S. C	122.4	64
Charleston Bridge	14	3.7	White Woman Landing, S. C	123.9	65.1
Big Patten, Ga	20.7	5.6	Cotton Tree Landing, Ga	128.3	67.7
Purysburg, S. C	22.6	6.5	Brown's Landing, S. C	130.4	68.8
Beck's Ferry, S. C	26.5	8	Stony Bluff, Ga	131.5	69.3
Bay Bush Point, Ga	30.7	11.7	Little Hell Landing, S. C	133.5	70.8
Keiffer Landing, Ga	32.6	13.2	Confederate Obstructions	137.2	74.4
Ebenezer Landing, Ga	34.4	14.1	Rattlesnake Camp, S. C	140.9	76.7
Seine's Landing, Ga	37.4	15.2	Steel Creek Landing, S. C	141.4	76.9
Berry's Landing, Ga	38	15.5	Steel Creek Landing, Ga	141.7	77.1
Gaffney's Landing, Ga	38.6	15.8	Ellison's Landing, Ga	143.6	78.1
Frying Pan Landing, Ga	39	16	Brigham's Landing, Ga	144	78.3
Groover's Landing	45.8	19.8	Buxton's Landing, Ga	147	79.1
Sisters' Ferry, Ga	47.1	20	Griffin's Landing, Ga	147.4	79.2
New Landing, S. C	48.8	20.8	Chandler's Landing, Ga	148.6	79.6
Ku Klux Landing, Ga	51.2	21.6	Hancock's Landing, Ga	152.2	81.2
Trowell's Landing, Ga	51.9	21.7	Dog Ferry, Ga	152.9	81.7
Bostwick's Landing, S. C	55	24.2	Flowery Gap Landing, S. C	156	83.7
Stokes' Landing, S. C	55	24.2	Point Comfort Landing, S. C	157.6	84.6
Parachuchla, S. C	55.2	24.3	Demeries Ferry, Ga	161.1	86.5
Mount Pleasant Landing, Ga	59.9	27.4	Shell Bluff, Ga	162.6	87.1
Porter's Landing, Ga	61.9	27.8	Bent Lake Landing, S. C	163.8	87.6
Enoch's Landing, Ga	67.2	30.2	Gray's Point Landing, S. C	169.6	91.7
Hudson's Ferry, Ga	68.5	30.5	Eagle Point Landing, Ga	171.6	92.8
Black Creek Landing, Ga	69.8	31.2	Lower Silver Bluff, S. C	173.6	93.7
Martin's Landing, S. C	73.1	32.9	Boat Yard Landing, S. C	174.3	94.3
Poor Robin Landing, Ga	80.4	38	Upper Silver Bluff, S. C	174.9	94.5
Haga Slaga Landing, Ga	90.7	44.3	Hungry Swamp Landing, S. C	180.7	98.7
Brier Creek, Ga	93.2	46.4	Belmont (upper) Landing, Ga	181.8	99
Matthew's Bluff, S. C	100.7	50.4	Bradford Landing, S. C	184.9	100
Cohen's Bluff, S. C	101.1	50.6	Twiggs's Landing, Ga	187.2	101.7
Saxon's Landing, Ga	103.9	52.7	New Savannah, Ga	189.7	102.8
Black's Landing, Ga	108	54.9	Mason's Landing, S. C	191.2	103.5
Valley Bluff Landing, Ga	108.8	55.2	Sand Bar Ferry, S. C	198.6	107.9
Mill's Landing, Ga	112.3	57.6	Augusta, Ga	202.5	109.6

DIRECTION OF RIVER.

From Augusta to Savannah the immediate river valley (that part overflowed by high freshets) is of an unknown width, varying probably from 3 to 10 miles. The index map shows the borders of this valley in a number of places. A line drawn as nearly as may be down the center of this valley is about 118 miles long. It will be seen that the channel of the river is about one and seven-tenths as long as the immediate river valley. In a large number of places more than a 3-miles run along the channel is necessary in order to gain 1 mile. In the 4 miles between Gold Wire and Sisters' Ferry reaches is a length of 11 miles by the river channel. Many of the reaches are very direct. The channel between the 142 and the 155 mile point is only

very slightly longer than an air-line. The general course of the river is quite direct. Savannah bears from Augusta, S. 27° 45′ E. The following points are practically on an air-line between the two cities: Mulberry Grove at 11 miles; Hudson's Ferry at 68½ miles; Hancock's Landing at 152 miles, and Silver Bluff at 175 miles. The widest distances from the air-line are as follows: Twiggs' Landing at 187 miles is 3 miles to the right; Haynes' Cut at 158 miles is 2 miles to the left; White Woman's Point at 124 miles is 9 miles to the left; Cohen's Bluff at 101 miles is 6 miles to the left, and the lower end of Sisters' Ferry reach at 43½ miles is 6 miles to the left.

SLOPE OF RIVER.

At low water and low tide, there is a fall between Augusta and Savannah of 108 feet or 0.533 feet per mile. Drawing a straight line upon the profile from the low-water point at Augusta to that at Savannah, we have a line representing a mean low-water slope of the river. Within the first 65 miles below Augusta there is no point of the low-water surface which varies more than 1½ feet from the line of mean slope, and within the first 35 miles there is no point varying more than 0.8 of a foot from this line. At the "obstructions," at 65 miles below Augusta, the surface of the water begins to drop below the line. Seventy miles further down, the water surface is 8 feet below the line. From this point, the distance below the line gradually lessens until Savannah is reached. The following table shows the distance in feet of the low water below the line representing the mean slope of the river between Augusta and Savannah:

Distance from Savannah.	Low water below line of mean slope.	Distance from Savannah.	Low water below line of mean slope.
Miles.	*Feet.*	*Miles.*	*Feet.*
0	0.0	110	4.2
10	3.5	120	3.0
20	7.2	130	2.5
30	6.4	140	0.5
40	6.5	150	1.4
50	7.5	160	1.0
60	6.4	170	0.3
70	7.0		
80	6.8	180	—0.5
90	5.6	190	0.0
100	4.6	200	0.0
		205	0.5

While the mean slope for the river is 0.533 feet per mile, that for the first 65 miles below Augusta is 0.545 feet; for the next 70 miles it is 0.636 feet; for the next 50 miles it is 0.503 feet, and for the last 17½ miles it is 0.162 feet. The closest inspection of these tables or of the profile submitted herewith, will fail to reveal even a trace of the fabled fall supposed to exist between Augusta and Shell Bluff, presumably in the neighborhood of Butler's Creek. I beg leave to submit the following table, showing a direct comparison between the results of the survey made in 1880 by S. L. Fremont, assistant engineer, and that made by myself in 1889. Of this table, the first three columns are taken directly from Mr. Fremont's report as published in Report of Chief of Engineers, U. S. Army, for 1881, on page 1102. The fourth column has been deduced by myself from the two preceding:

Places.	Survey of 1880.			Survey of 1889.		
	Distance.	Fall.	Fall per mile, mean.	Distance.	Fall.	Fall per mile, mean.
1	2	3	4	5	6	7
	Miles.	*Feet.*	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Augusta to Silver Bluff	18	22.423	1.24	27.0	15.1	0.55
Silver Bluff to Haynes' Cut	27	29.056	4.08	16.9	9.8	0.58
Haynes' Cut to Steel Creek	33	10.297	0.31	16.3	7.7	0.47
Steel Creek to Savannah	170	68.624	0.40	141.7	75.4	0.53
Augusta to Savannah	248	130.400	.....	202.5	108.0	.....

It should be mentioned that at the survey of 1880 no attempt was made to measure the channel. Levels were, however, run from bench-marks on the Port Royal and Augusta Railway to the river at Augusta, Silver Bluff, Haynes' Cut, and Steel Creek.

RIVER VALLEY.

Along Beech Island (which lies along the left bank of the river, between Horse Creek and Hollow Creek), or to Silver Bluff, the average height of the river bank is about 16 feet above low water. Immediately below Silver Bluff, and for the next 40 miles, the banks vary but little from 10 feet in height at low water. For the lower 135 miles of the river, the banks will average about 8 feet in height at low water. Along Beech Island the river banks are composed, in the main, of a very fine sand mixed with a small quantity of clay. The soil is of such a nature as to afford very little resistance to scouring. Were the banks lower, the trees and bushes with which they are covered would protect them in a great measure. As it is, the trees are being constantly undermined and dropped into the river, either to float away or to obstruct the channel, but not to protect the face of the caving bank. Along this section of the river places were shown me where the river has gradually moved more than 1,000 feet within the last twenty years. Swamp meadows, with surface 15 to 20 feet above low water, now occupy the position of the channel of twenty years ago. At Blue House Bar the channel moved to the left a distance of 100 feet between August, 1886, and June, 1887; and nearly 400 feet more between June, 1887, and June, 1889. At a number of places above Silver Bluff cut-offs have occurred within the last few years. Above Stingy Venus, and particularly so above Twiggs' Bar, the river is very wide, (from 500 to 900 feet), while from that point to tide-water it averages only about 300 feet. Wide sand-bars border the river for the upper 25 miles, some of them nearly a mile long by 1,000 feet wide. These bars grade from mud and soft sand to gravel. Farther down the river few sand-bars occur. The bed of the river, both here and below, is of sand. Coarse gravel, and in three or four places in deeper water, rock is found in limited quantities. In shoal water, particularly on the bars and in the reaches, the river bottom is of a fine rolling sand, which seems to lie in low ridges across the current. A careful study of any particular locality would doubtless show a wave motion in the progression of these sand ridges down the stream. Below Beech Island the river banks contain more clay and less sand, and are quite firm. In many places, little scouring takes place at ordinary stages of water, even when the current impinges quite sharply against the banks. In a few places, where the banks contain more sand, caving is constantly going on. Below Butler's Quarry, 3 miles above Augusta, the river banks afford stone at only the following places: Shell Bluff, Griffin's Landing, Little Hell, Stony Bluff, and Sisters' Ferry, Georgia. Except at Sisters' Ferry, where there is one thin layer of a soft slate (?) and at Stony Bluff, where ledges several feet in depth, composed of a very dense quartzite occur, the rocks of the valley are of various marls, too fragile to be of ordinary use.

VILLAGES.

Between Augusta and Savannah no villages nor considerable collections of houses are found except at Purysburgh, S. C., about 23 miles above Savannah. Here are located, besides the freight-house at the landing, a store, a saw-mill, one or two dwellings, and a half dozen negro cabins. The mill has not been in operation since 1888.

CROSSINGS.

There are no highway bridges across the river below Augusta. Railroads now cross it in only two places. Sketches of their bridges are shown on the general maps. Through each bridge is a draw over a channel of sufficient width and depth. The following public ferries are maintained across the river: Sand Bar Ferry, 193.6 miles; Brown's Ferry, 130.7 miles; at Matthew's Bluff, 100.6 miles, and at Sisters' Ferry, Georgia, 47.2 miles. Private ferries are used at a number of other points from time to time.

GENERAL CHARACTER.

The trees along the river near Augusta are mainly cottonwood, maple, and willow, on or near the newer or lower lands. Where the river has not had its bed for a long term of years, oaks, sycamore, ash, elm, locust, iron-wood, birch, hickory, and a few sweet gum trees are found. Among the trees, particularly among those close to the river bank, various kinds of brush are found forming dense thickets. Near the upper end of the river, neither the large overhanging willows nor the thick cane-brakes, so often

met with lower down, are found. Below Beech Island the maples gradually disappear, and gums and cypress take their place. In the upper valley few pines are found. From the reaches down, short-leaf varieties appear.

For nearly half the direct distance between Augusta and Savannah, the river crowds close to a bluff nearly 100 feet high bordering the right-hand side of the valley. Along this bluff reaches are found which are very straight, from 500 to 600 feet wide and comparatively shoal. The more tortuous parts of the river are much deeper and narrower and have but slightly more fall per mile than the reaches. It is usually expected that the shoal places of the river have the greatest slope. Such is, however, not always the case. A wide part of the river may be shoal enough to impede the passage of boats and have no more fall per mile than a narrower river with a greater depth. The width of the river for its whole length averages about 350 feet at ordinary stages of water. Long stretches of the river occur which are not more than 200 feet wide. Places in King Creek and Haynes' Cut give a width of not more than 90 feet. Taking the river as a whole, it averages at least 10 feet at deep low water. Only six places show from the profile to have less than 4 feet of water; 15 places to have less than 5 feet, and only about 45 places to have less than 6 feet. It must be borne in mind that the soundings were taken at stages varying from 1 to 8 feet above low water. A number of crossings, as one in King Creek showing not more than 6 feet of water on a bed of soft sand, would doubtless show a greater depth even after the river had fallen 3 feet to low water. Many crossings where my soundings would indicate bad bars, give the steam-boats no trouble, even at lowest water. As the river falls it grows narrower and the velocity of water in the channel is often very much increased. As a result, the bars wash out in many places.

OBSTRUCTIONS TO NAVIGATION.

A clear channel 5 feet deep at low water is no unreasonable requirement for a river of the width and depth of the Savannah. A channel 4 feet deep might be prepared and maintained at a less expense, but the commerce of the river will no doubt warrant a larger outlay for a deeper channel. The heaviest and most important river traffic comes at or shortly after the season of lowest water. To carry this advantageously boats of large hulls or of deep draught are necessary. Boats much larger and wider than those now in use could not well be handled in the narrower and more tortuous parts of the river. For the ordinary boats of this river the net capacity of the boat is increased 60 to 75 tons for each additional foot of draught. The obstructions encountered at low water by a boat drawing 5 feet consist of sand, gravel, and clay bars, snags, logs, and overhanging trees. Besides removing the snags, etc., and deepening the bars, it will be necessary, in order to maintain a channel, to prevent cut-offs from forming at three or four places, and to stop a number of break-overs.

Of the snags in sight when the survey was made I have counted about 675 which obstruct navigation. Perhaps 2,500 snags are shown on the maps, but many are remote from the channel. My attention was called by the pilots to about 180 ground logs which are dangerous to navigation. Many of these logs are doubtless only known by tradition. The present needs of navigation require the cutting of about 250 trees along the banks. These are only the trees which might be struck by boats while in good water, or which are liable to so fall as to temporarily block the river. It should be remembered that with every snag (which is an obstruction to navigation) in sight at ordinary stages of water a number of unseen snags are found which require removing. No very accurate ratio between the number of snags in sight and the number obstructing navigation can be given. It is probable, however, that for every snag enumerated above as such, one day's work with a good snag-boat will be required to place the river in a first-class condition. This will include the removal of logs and overhanging trees. Subsequent to the examination, during the months of September, October, and November, 1889, the United States snag-boat *Toccoa* did efficient work in removing snags and logs from the river from the Port Royal and Augusta Railway Bridge to Boat-Yard Landing and in the vicinity of King Creek. Many of the snags shown on my map were removed. The snags remaining, which now most obstruct navigation, are found along Beech Island, in the vicinity of Gray's Point, and from Little Hell to Brier Creek.

The following is a tabulated list of obstructions which should be removed and break-overs and cut-offs which should be stopped, in addition to the removal of the obstructing snags, etc., previously mentioned. As to the bars at Sand-Bar Ferry and Blue House, the estimates given in the following table are based upon examinations made in November, 1889, tracings of which bars are submitted herewith attached to Sheets Nos. 1 and 2 of details:

Number of obstruction.	Distance from Savannah.	Number of detail.	Name.	Nature of obstruction, etc.	Length.	Fall in distance given.	Least depth in channel, 80 feet wide.	Width of river.	Description.	Remarks.
	Miles.				*Feet.*	*Feet.*		*Feet.*		
1	202.4	1	Gardner's Bar....	Sand-bar.....	1,800	0.3	3.0	650	The worst part of this shoal is a sand-bar about 500 feet below wharf at Augusta, extending from right bank nearly to end of Dam. No. 3, or about 300 feet.	Dams Nos. 3, 4, 5, and 6 should be raised to about 2 feet above low water, and bank protection in form of short opposing jetties should be built on right bank, at intervals from the city wharves to Courses Bar, narrowing channel along the city to about 325 feet.
2	201.1	1	Courses Bar.....	....do	600	0.2	4.5	675	Sand-bar has made out from right bank above Dams Nos. 8 and 9, choking up channel. Boats now pass the point of this bar by making a short difficult turn.	Dams *b* and Nos. 1, 7, 8, 9, and 10 should be raised to 2 feet above low water, and Dams Nos. 7, 8, 10, 11, and 12 extended 20 to 80 feet each, narrowing channel to 325 feet.
2½	200.0	1	Horse creek.....	Caving bank.....	.....	.....	.....	600	A caving bank tends to form a bight upon wrong side of the river.	Farther caving would be prevented by construction of three short spur-jetties in false bight.
3	198.8	1	Sand-bar, Ferry bar	Sand-bar.....	600	0.2	4.0	700	Bar of soft sand formed across river 500 feet below Dams Nos. 2 and 3. See tracing accompanying sheet 1 of details.	Dam No. 2 should be raised about 1½ feet, and a pair of new dams built about on a line with Sand Bar Ferry Landings. Channel should be narrowed to 325 feet. Progression of sand-bar down-stream may require still other dams below.
3½	198.0	2	.....	Caving banks.....	.....	.....	.....	600	Caving bank is making a bad bight 1,000 feet below the Port Royal and Augusta Railway Bridge.	Bank protection in form of one or two spur-jetties should be built.
4	197.6	2	Blue House Bar..	Clay-bar.....	300	0.2	4.1	450	This is a hard bank uncovered by shifting of river to left above old bar.	A low dam 200 to 250 feet long should be built from sand bar on right bank opposite Dam No. 9, contracting channel to 325 feet.
5	197.4	2	....do	Caving bank.....	300	0.3	.....	800	Left bank caving opposite Dam No. 6, caused by forcing channel through old Dam No. 4. Bank of soft sand 20 feet high.	Will probably be necessary to put in bank protection in form of a jetty. See tracing attached to Detail No. 2.
6	194.4	3	Canoe Gut Bar....	Sand-bar.....	2,800	0.7	2.0	650	This is a long stretch of wide river over a bed of soft sand. (NOTE.—In January, 1890, this bar gave more than 4 feet at low water.)	Five or six spur-jetties should be run out from the right bank at height of about 1 foot above low water, leaving 325 feet channel along left bank. Two short spur-jetties should be built to protect left bank.

Number of obstruction.	Distance from Savannah.	Number of detail.	Name.	Nature of obstruction, etc.	Length.	Fall in distance given.	Least depth in channel, 80 feet wide.	Width of river.	Direction.	Remarks.
	Miles.				*Feet.*	*Feet.*		*Feet.*		
7	187.4	4	Twiggs' Bar.....	Gravel-bar.....	1,200	0.3	3.5	600	Channel has changed from sand bottom near right bank to gravel bottom near the left by cutting away of the left bank above.	Three or four spur-jetties should be built out from the right bank to a height of 1 foot above low water, narrowing channel to about 300 feet.
8	186.6	5	Half Guinea Bar..	Sand-bar.....	500	0.1	4.0	500	Sand-bar formed across river dividing channel into two parts on a crossing.	Three spur-jetties built from the left bank below mud flat would improve this bar.
9	183.2	.....	Bailey's Point	Caving bank.....	1,800	.....	.....	300	For 500 feet, at 183.2 miles, the channel is separated by only about 100 feet of bank, 13 feet high, from that at 181.9 miles. The fall between these points is about 0.5 of a foot at low water. Bank on upper side is caving badly. No surface cut has yet appeared. Freshet of 1888 ran about 12 feet deep across this bank.	For about 1,800 feet this bank should be revetted. A cut-off at this place would doubtless lower the water 0.5 of a foot on bars immediately above.
10	179.0	6	Head of Stingy Venus.	Logs and sand....	200	0.1	4.5	350	The shoal here is caused by ground logs and sand on a crossing.	Upon removal of the logs and snags the sand would wash out, giving a good channel.
11	156.1	7	Flowery Gap Bar.	Sand-bar	200	0.1	4.0	500	Sand-bar formed on a crossing at wide part of river.	Two or three spur-jetties from left bank would straighten crossing and give sufficient water on bar.
12	144.0	8	Brigham's Bar....	....do	1,500	0.3	3.0	475	Sand-bar formed on a crossing in a wide, straight river.	Four or five spur-jetties from right bank would improve river. Crossing could be made lower down, where river is deep from bank to bank. Five or six piles of old pile-dam near left bank should then be removed.
13	140.7	.....	Little Boggy Gut.	Break-over	.....	.....	.....	.....	This is a break-over of considerable size.	Could be closed by lopping trees into its bed near upper end.
14	134.3	.....	Sweetwater Creek	....do	.....	.....	.....	.....	A break-over 50 or 60 feet wide, open at low water, about one-half mile long, cutting off 2 miles of river; fall, 1.7 feet.	Should be closed, together with three smaller guts, at about 134 miles. A row of piling will be necessary across upper end of creek.
15	125.6	.....	Big Randall Point.	Caving bank	1,200	.....	.....	250	Right bank caving badly. Channel separates from that at 125 miles by bank 400 feet wide and 12 feet high. Fall, 125 to 126 millimeters = 0.4 of a foot.	Bank should be protected by lopping trees on top to protect face.

16	115.4	.....	Head of King Creek.	Point	100	0.2	.....	.....	A narrow point, about 200 feet long, deflects water into old river and makes it very difficult for boats entering and leaving King Creek.	This point should be cut off about 200 feet back. It has a foundation of stiff clay.
17	111.6	.....	Swift Creek and below.	Break-over	1,500	.....	.....	.....	From Swift Creek, at 111.8 to 111.5 miles, the bank is caving and break-overs forming connecting with river at 109.8 miles. Fall, 1.6 feet, from 111.8 to 109.8 miles.	These break-overs should be closed and the bank for 1,500 feet should be protected by lopping timber along face.
18	107.9	.....	.....	....do	.....	.....	.....	.....	A wide break-over just below Black's Landing diverts considerable water from the river above a shoal.	This and one or two other break-overs in the next one-quarter mile below should be closed.
19	104.5	.....	.....	Gut.....	.....	.....	.....	.....	A gut 25 feet wide enters the river at about 103 miles. Fall, 1.2 feet, between 104.5 and 103 miles.	Gut should be closed by a row of piles and the bank protected for the next 1,500 feet below by lopping trees along bank.
20	94.3	.....	Swift Creek.....	Break-over.....	.....	.....	.....	.....	A break-over about 25 feet wide and 3 deep connecting with Briar Creek.	Should be closed by piling. A small break-over just below should also be closed.
21	93.8	.....	.....	....do	.....	.....	.....	.....	Three break-overs in this bight, each 15 to 20 feet wide.	Should be closed.
22	88.3	.....	Thompson's Cow Fold Point.	Cut-off.....	.....	.....	.....	.....	A caving bank will cause a cut-off unless stopped; distance across point only about 400 feet; two or 3 break-overs have already started.	Bank should be protected for about 1,200 feet, and the break-overs closed.
23	87.5	.....	.....	Gut.....	.....	.....	.....	.....	A deep gut about 25 feet wide	Should be closed.
24	84.4	.....	.....	....do	.....	.....	.....	.....	A gut 25 feet wide extending across narrow point.	Do.
25	83.5	.....	.....	Break-over	.....	.....	.....	.....	A break-over 40 feet wide by 2 feet deep at low water, through a bank 6 feet high. The break-over is only about 900 feet long; has a fall of about 0.7 of a foot, and cuts off nearly 1 mile of river; below break-over bank is caving; hardly 300 feet separates channels on opposite sides of point.	The break-over should be closed with a row of piles, and the bank protected for about 1,400 feet by lopping trees along the top.
26	75.2	.....	.....	Caving bank.....	.....	.....	.....	.....	Bank 6 feet high, caving badly; neck of point only 500 feet wide; distance around by river 1¼ miles; fall, 1.1 feet.	Bank should be protected for abou 1,000 feet.
27	71.8	.....	.....	Guts.....	.....	.....	.....	.....	Three guts cutting off a large round	Guts should be closed.
28	63.6	.....	.....	....do	.....	.....	.....	.....	Two wide and deep guts leave river here and connect with head of Gold Wire Reach.	Should be closed by piling.
29	58.2	.....	.....	....do	.....	.....	.....	.....	Three guts cutting off 1½ miles of channel.	Should be closed.
30	57.2	.....	.....	Caving bank	.....	.....	.....	.....	Caving bank on upper side of neck 500 feet across bank 7 feet high. Distance around by river about 1 mile; fall, 0.8 of a foot.	Bank should be protected for about 1,400 feet.
31	55.7	.....	.....	Gut.....	.....	.....	.....	.....	Gut 25 feet wide	Should be closed.

Number of obstruction.	Distance from Savannah.	Number of detail.	Name.	Nature of obstruction, etc.	Length.	Fall in distance given.	Least depth in channel, 80 feet wide.	Width of river.	Description.	Remarks.
	Miles.				*Feet.*	*Feet.*		*Feet.*		
32	53.4	.....	Hog Nose.....	Caving bank.....	.....	.....	.....	.....	Bank caving; 6 feet high; distance across the neck, 80 feet: distance by channel 0.6 of a mile; fall, 0.5 of a foot.	Bank should be carefully revetted for about 1,000 feet; current is very swift on upper side.
33	44.0	.....	.....	Break-over.....	.....	.....	.....	.....	Two guts, more than 40 feet wide by 4 feet deep, just above shoal place in river.	Should be closed.
34	42.6	.....	.....	Gut.....	.....	.....	.....	.....	A deep gut about 30 feet wide and 700 feet long across point.	Do.
35	41.5	.....	.....	....do	.....	.....	.....	.....	A gut 10 to 20 feet wide connecting with river 1½ miles below.	Do.
36	40.6	.....	.....	Break-over.....	.....	.....	.....	.....	Three break-overs into Frying Pan Lake.	Do.
37	33.1	.....	.....	....do	.....	.....	.....	.....	Break-over 25 feet wide from Carolina bight.	Do.
38	30.3	.....	Reezer Creek.....	Creek.....	.....	.....	.....	.....	This creek is a gut 30 feet to 50 feet wide and 3 feet deep. It is about one-half mile long and has a fall of 1.2 feet. The river is 1½ miles long from the upper end of the creek to the lower end, and is very swift.	Should be closed with piles.
39	17.1	.....	.....	Wreck.....	.....	.....	.....	.....	Wreck of flat-boat loaded with wood, in center of channel. Top about 1 foot below low water. In way of rafts.	Should be taken out.

A number of detailed surveys, not mentioned in the list above, was made. Three of these were plotted. (See details Nos. 9, 10, and 11.) Detail No. 9, at Lower Three Runs Creek, shows a channel 80 feet wide, with easy curves, having a minimum depth of 5.2 feet at low water. Its center is about half a foot deeper. Burton's Ferry Bar, detail No. 10, gives about the same depth of water. The Charlestown Bridge Bar, detail No. 11, has evidently not been worked to its best advantage by the pilots. The boats start the crossing too soon and make it too abruptly in coming down. In the best channel the bar will give 5.5 feet of water at low river and low tide.

CHANGES SINCE 1880.

Of the seventeen bars and obstructions upon which improvement was recommended by Mr. S. L. Fremont, assistant engineer (see Report of Chief of Engineers, U. S. Army, for 1881, page 1094), only nine are included in my list, as being at the present time obstructions to navigation. On the other eight mentioned by Mr. Fremont, good water is now found. Bugg's Bar carries about 7½ feet in a straight channel. "Twiggs' Lower Bar" is included in the above list of obstructions under the name of Half Guinea Bar. Haynes' Cut affords not less than 9 feet in the channel. No obstructions are necessary in the old channel at the right of the cut. The Confederate Obstructions at 137.2 miles have been removed sufficiently to afford a good channel near the left bank. Hack's Bar has totally disappeared. Lower Three Runs and Burton's Ferry Bars show about 5.2 feet each. (See accompanying details, Nos. 9 and 10.) The shoal which existed at White Woman's Point now shows about 6 feet of water. King Creek now takes nearly the entire flow of the river at low water. The removal of the row of piles at the head of the creek and of the trees, snags, and ground logs by the United States snag-boats has given a fairly good channel through the creek. The channel is in a few places only about 90 feet wide. Some parts of it are quite tortuous. The old river has filled up so rapidly that no boat can reach Herschman's Lake at low water. No survey of the old river toward the "lake" was made, the improvement of that part of the river being out of the question. The old river above Herschman's Lake is only used now at times of freshets.

WRECKS IN CHANNELS.

A large number of wrecks is found between Augusta and Savannah. While most of them lie close to the shores or away from the channel, a few are so placed as to be possible sources of danger to navigation. A sunken flat-boat just below Bugg's Bar, at 192.1 miles, lies close to the left side of the channel, with deep water on either side. It is high enough to be dangerous. A sunken flat, which just shows at low water, lies well into the river opposite the new mouth of Hollow Creek, at 176.2 miles. The channel, in passing the wreck, makes a bend to the right. Another flat is found 2 miles below, in the middle of the river, near Boat Yard Landing. The channel passes to the left of the wreck. The wreck of the steamer *Edgefield* is in the middle of the river half a mile above Burton's Ferry. The channel, however, passes it some distance to the left. Just below Haga Slaga, at 90.5 miles, is the wreck of the steamer *Hamburg*, close beside the channel. At Big Patten, 20.7 miles, is the wreck of the steamer *Eclipse*, in the middle of the river. The channel used at low water is at the right of the wreck. Lower down, and within the limits of Savannah Harbor, are two other wrecks, which are mentioned by the river pilots as being troublesome. The first is to the right of the channel, just below the city water works, and the other close to the left of the channel, opposite the new Central Railroad wharves. The building of these wharves along the right bank of the river crowds the channel to the left, particularly when boats are lying at the wharves, as in loading. At such times it is difficult for river boats to pass the wrecks at low water.

CONDITION OF OLD WORKS.

The condition of the river at the various works of improvement and of the works themselves on June 1, 1889, as shown from the maps not completed until the latter part of the year, is given below. The five dams built at Gardner's Bar in 1883 were still in good condition. Dam No. 2 averaged about 0.5 of a foot above low water (a stage 1½ feet above the low water of 1883). Dam No. 3 averaged about at low water level. Dam No. 4 had a break some 40 feet long near outer end. Its inner end averaged about 0.5 of a foot above low water. Dam No. 5 had two or three small breaks with mean crest at about low water. The inner end of Dam No. 6 was about 0.5 of a foot above, while the outer end was somewhat below water. The shore protection of each of the dams was nearly or quite covered with sand and mud. The 1,375 feet of bank protection opposite these dams and along the city front were somewhat broken. This protection, in the form of loose stone only and placed mainly at the

toe of the bank, had in most cases succeeded in protecting the lower part of the bank from scour. The bank above the protection was, in many places, badly eroded by the freshets of July, 1887, and of September, 1888. Between this shore protection and the ends of the dams was a channel from 350 to 375 feet wide. Good water was found in a narrow channel up as far as Dam No. 5. Here the channel shoaled up to about 3 feet, a sand-bar having made out from the shore opposite to and just below the end of Dam No. 3. Once over this shoal, which is not more than 400 feet across, good water is found along the wharves. Considerable trouble has been experienced by loaded boats in passing this shoal. Much of the shoal which then existed at this point was no doubt due in a large measure to the obstruction offered by the bridges immediately above the wharves. All of the dams at Course's Bar were in good condition. Dams Nos. 7, 8, 9, 11, and "b" were from one-half of a foot to 2 feet above low water at their inner ends, while their channel ends were from 0.5 of a foot to 2.5 feet below. Dam No. 7 was about 0.8 of a foot above low water for its entire length and Dam No. 12 from 1 foot to 3 feet above. The shore ends of all dams, except No. 12, were already covered with sand and mud. The upper pairs of dams leave a channel 350 feet wide; the second, 400 feet, and the lower pair, 480 feet. A good channel was found nearly as far down as Dams Nos. 8 and 9. A sand-bar 4 feet below water made out from the right bank just above Dam No. 9, extending to within about 50 feet of the opposing dam. Immediately below good water is again found. Beyond giving a tortuous channel, this bar has not impeded navigation even during the low water of 1889.

For 1,800 feet below the mouth of Horse Creek the left bank of the river was washed away, mainly by the freshet of 1888. For nearly half this distance the erosion extended about 100 feet into the bank. This cutting had caused at that place a false bight, which at stages of water above about 15 feet caused the current to cross the river and to impinge strongly against the right bank 1 mile lower down, just above Sand-Bar Ferry. Here the old shore protection built in 1885, opposite Dam No. 1, was washed away. The bank back of it was cut away for about 50 feet. Dam No. 3, built also in 1885, 500 feet below, was washed away down to its bottom course of fascines. The bank back of it was cut away for nearly 150 feet. Dams "x," Nos. 1, 2, and 4, were in a good state of repair. The shore end of each of these dams was deep in the mud and sand of the bank, and the river bank was making rapidly from the left between them. The crest of each of these four dams averaged at about the height of low water. A sand-bar lay across the channel from the line of Dam No. 1 half way to Dam No. 2. Soundings taken at a stage of 2½ feet above low water showed about 4 feet at low water over this bar. The channel giving the best water was about 100 feet to the left of the anchor buoy of the ferry, while the channel then used by the river boats was close to the right side of the buoy, in about 1.2 feet less of water. Four months later the bar had dropped down nearly 300 feet, and gave only about 3 feet at low water. At the Port Royal and Augusta Railway Bridge, half a mile below Sand Bar Ferry, the left bank had washed away in the neighborhood of the bridge for about 50 feet. Good water existed through the draw to the left of the pivot, but the main current of the river passed 100 feet farther to the left. Owing to the position of the draw at the edge of the channel, the passage of the bridge at high water by the river boats is now considered dangerous. Some works of contraction must be put in from the left bank in the vicinity of the bridge or the channel through the draw will become shoal and dangerous at low water also. I understand that preliminary steps have been taken by the Port Royal and Augusta Railway to protect their bridge and to preserve their channel. Above Blue House Bar the tendency of the river has been for some years to cut away the left bank of the river. Between August, 1886, and June, 1887, the low-water line had moved back about 100 feet, and the line of the top of the bank about 200 feet. The freshets of 1887 and 1888 eroded the bank nearly 400 feet further. In May, 1889, the channel, instead of passing to the right of Dams "a" and No. 2, as in 1885, passed for 200 feet wide to the left. While a large portion of the flow of the river passed over, through, and to the left of Dam No. 4, the boat channel passed close to the right of the dam. Just below the outer end of Dam No. 4 the channel passed between two high sand-bars, and impinged sharply against the right bank at a point well protected by small trees at and above water-line. Although the channel was narrow and dangerous, boats could find about 3½ feet at low water. In May, 1889, Blue House was the worst bar on the river. Dams Nos. 3 and 5, built in 1885, and Dams Nos. 1 and 3½, built in 1887, all upon the right-hand side of the river, were deeply covered with mud. Dam "a" of 1887 had its crest at about 1 foot above low water. Its shore protection was entirely washed away. Dam No. 2 of 1885 was in a good state of repair and somewhat above low water. Its shore protection, built in 1887, had disappeared except that portion which was less than 2 feet above low water. Of Dam No. 4, originally nearly 400 feet long, only about 120 feet of the outer end remained in repair. Most of the shore protection had washed away, leaving only an island about 8 feet high above low water, with crest covered with loose riprap stone. The middle portion of the dam

for about 200 feet was a total wreck. Most of the brush seemed to have been washed away, leaving a surface of stone either upon a sand bottom or upon a single course of fascines, under 0.0 foot to 5 feet of water at low stages. Five hundred feet below Dam No. 4 only a depth of about 2 feet of water was there found. Just above Blue House Bar the greatest erosion of the left bank occurred, at the head of a depression 10 feet or 12 feet deep, known as Miller's Dead River. Whether this was once a river-bed or merely a breakover is uncertain. The upper end of this depression was deeply eroded; but at 600 feet from the river bank and below it was filled by the last freshet with sand, from 1 foot to 4 feet deep. It is not at all probable that either this high water breakover or the one about 3 feet deep on the same side of the river, half a mile higher up, will ever become the bed of the stream, inasmuch as the upper end of each is held by a clay bank of considerable elevation above low water. For the condition of the old works and the adjacent river, see details Nos. 1 and 2, sheets 1 and 2, accompanying this report.

JETTY WORK IN 1889.

Work at Blue House Bar was begun September 16, 1889, and carried on by contract. About September 1 the channel to the right of Dam No. 4 became choked by the sand-bar above, and another had opened across the broken part of the dam nearer the left bank. The island, covered with stone, existing in place of the shore protection of Dam No. 4, had been washed away, dropping its load of stone in 3 feet to 6 feet of water. A new dam (No. 6) was built from the right bank, connecting with the channel end of old Dam No. 4. Dam No. 6 is about 580 feet long, and 1.5 feet above low water, except for about half the distance, where the sand-bar was already at about that height. Dams Nos. 8, 9, and 10 were built as spurs, projecting from the left bank at the head of the bar, for the purpose not only of deepening the channel over a hard lump opposite Dam No. 9, but also for protecting the upper parts of the left bank from further scour. These dams were built to a height of about 1.5 feet above low water. The bank on the line of each dam was trimmed to a uniform slope, and the dam extended back from 35 to 60 feet beyond the top of the bank. Upon the face of the slope, and on the upper side, extending from 10 to 20 feet back from the top of the bank, the dams were widened to 35 or 40 feet, forming the shore protection. (See profiles and plans of Dams Nos. 8, 9, and 10, Blue House Bar, 1889, on file in this office.) The south ends of old Dams "a," Nos. 2 and 4, were removed in order to widen the new channel to 350 feet. For the condition of the work and the bar on November 15, 1889, see tracing attached to Detail No. 2 of this report. On this tracing those parts of the dams not entirely removed are shown in dotted lines. Position of loose rock on or near the sites of the old dams is shown thus (x).

Work at Sand Bar Ferry was begun on October 25, and finished about December 1, 1889. Dam "a," 1889, was built across the lower end of old shore protection "a" on line of Dam No. 1. Dam No. 3, 1889, was built on line of Dam No. 2, practically across the lower parts of old Dam No. 3, which still remained under about 2 feet of water. These dams narrowed the channel to 350 feet. Dam No. 1 of 1885 was raised something over 1 foot, by addition of stone alone. All of this work was brought up to a height of 2½ feet above low water. Both dams "a" and No. 3 had shore protections similar to those constructed with the dams at Blue House Bar. Dam No. 3 extended back from the upper river bank about 70 feet to a ridge, reaching an elevation of about 20 feet. Dam "a" extended from the top of the river bank back about 200 feet across a sand flat to a ridge about 24 feet above low water. The right bank of the river under these dams is of an unstable mixture of sand and mud, on a mud foundation. A cut-off was already forming across the sand flat above Dam "a." It is expected that these shore protections will prevent further erosion of the right bank at these points. The tracing attached to Detail No. 1, sheet 1, accompanying this report, will show the location of the new work and the condition of the river at this bar on November 25, 1889. At the time the soundings were taken (as shown on the tracings referred to) the bottom course of mats of Dam No. 3 had just been put in place. The outer 130 feet of the dam was yet 1½ feet below low water. It was expected that after the dams were completed the water would materially deepen on this bar. Already nearly a foot had been gained. The bar at Sand Bar Ferry is composed of shifting sand. It is quite likely that the works already put in will cause the bar to shift lower down, making it necessary to continue the works of contraction. From a discussion of the examination in November, it seems probable that the ferry operated at that place will, at low water, be a serious obstruction to navigation. Considerable complaint has already been made concerning it. From the examination in November it appeared that the best water then existing was on a line with the cable buoys of the ferry. A number of times during the low water of 1889, before the dams were extended, it was found necessary, in order to pass the bar, to remove the cable buoys, and to drop the cable to the bottom of the river.

It is unfortunate that the ferry was originally placed in such a position that a bar

subsequently formed close above it. (Below Sand Bar Ferry no ferries are maintained that in any way interfere with navigation.)

CHANGES SINCE SURVEY OF 1889.

Since the survey and subsequent examinations made in 1889 the only changes of any importance which have taken place are: (1) A good channel has resulted from the work at Blue House Bar, and the bar at Sand Bar Ferry has deepened; (2) the channel has been much improved along Beech Island and in the vicinity of King Creek by the removal of snags during September, October, and November, 1889; (3) Canoe Gut Bar has deepened, and now gives sufficient water for the needs of navigation.

In regard to the latter bar it should be stated that it is doubtful, from the nature of the bottom and the shape and width of the river, if this deepening of the water will be permanent. In my opinion, in order to hold deep water across this bar, works of contraction will become necessary.

HISTORY.

The first survey of which I find any record was made by Capt. J. F. Gilmer, Corps of Engineers, U. S. Army, in April and May, 1853. The second survey made by the General Government seems to have been that made under the direction of Col Q. A. Gillmore, Corps of Engineers, U. S. Army, by Mr. S. L. Fremont, assistant engineer. The first appropriation was made for this river in 1881, and in 1882 the first work was done by the General Government. Previous to 1882 some work had been done by the city of Augusta and by the steam-boat owners. Two short pile dams were placed in the river near Brigham's Landing to improve that bar, and a row of piles was driven across the head of King Creek. The row of piles, from the right bank of the river above Brigham's Landing, has been covered up. Six piles of the lower dam remain in sight close to the left bank opposite the landing. The piles obstructing the present channel at the head of King Creek were removed by the United States snag-boat *Toccoa* in 1882 and in subsequent operations. Obstructions composed of piles and crib-work were placed across the river in the Seven Points, at 137 miles above Savannah, during the late war. A dangerous channel existed between these obstructions and the right bank from 1865 to 1882. By 1885 the snag-boat had opened up a narrow but safe channel at the left of these obstructions. The channel has since widened and is now perfectly safe at all stages of the river.

SLACKWATER NAVIGATION.

In the list of obstructions given in this report nine bars are mentioned as needing improvement. The following table shows directly their location with respect to Augusta:

Name.	Distance from Augusta.	Total fall from Augusta to foot of bar at low water.	Name.	Distance from Augusta.	Total fall from Augusta to foot of bar at low water.
	Miles.	*Feet.*		*Miles.*	*Feet.*
1. Gardner's Bar.....	0.1	0.5	6. Twiggs' Bar.....	15.1	7.8
2. Course's Bar	1.5	1.1	7. Half Guinea Bar	15.9	8.6
3. Sand Bar Ferry Bar...	3.5	1.8	8. Flowery Gap Bar	46.4	26.0
4. Blue House Bar	5.0	3.4	9. Brigham's Bar	58.5	31.3
5. Canoe Gut Bar	8.1	4.9			

Of the nine bars, seven are within 16 miles of Augusta, and five are within about half the distance. The two lower bars are less serious obstructions than those above. Noticing that the first five or the first seven bars are located so near together in distance and elevation, the subject of slackwater navigation suggests itself. Considering that an additional depth of 2 feet is necessary at Gardner's Bar, and allowing a slight slope to the pool formed, a dam with a lock of 6.1 feet lift located at the foot of Canoe Gut Bar would improve the first five bars at once, or a dam with locks of about 9 feet lift located below Half Guinea Bar would improve all of the bars in the upper end of the river. Only a movable dam offering little or no resistance to the water when open could be allowed. With the present low water at Augusta of 109.6 feet, a height of about 111.5 feet would be required at Augusta to give a good depth of water across Gardner's Bar. A dam located at any point below should have a crest when closed of about 111.5 feet, less 0.1 of a foot for every mile distant from Augnsta by channel. At no point of the dam should its crest be higher than the top of the

gates when fully closed. The locks themselves should be carried up to only about 118 feet. At either end of the dam proper shore protection should extend 300 to 400 feet back on the bank, to insure against the possibility of the structure being flanked during a freshet. A dam could not be located advantageously at New Savannah Bluff, nor at the place of any considerable elevation of either bank. The first five bars could be improved by a dam located at 9½ miles below Augusta, with a lift at low water of 6.6 feet. The river here is 500 feet wide, with banks 20 feet high. This would leave the crest of the dam when closed about 13 feet below the top of the bank. To improve the next two bars also a dam might be placed at 18½ miles below Augusta, with a lift of about 10 feet. The river is here about 400 feet wide, with banks about 15 feet high. The crest of the dam would be 5 feet below the top of the banks. A dam might be located at either of these places without necessitating the revetment of the river banks at adjacent points. The only care necessary would be to prevent flanking of dam. Slackwater in rivers always causes silting up of the river bed. This could, however, be nearly or quite counteracted by an intelligent manipulation of the gates in the dam below. Although slack water navigation is a practical solution of the problem, it would doubtless be much more economical to improve the bars by means of wing-dams.

GENERAL PLAN OF IMPROVEMENT.

The improvement of the river for the upper 15 or 20 miles is rendered extremely difficult by the very unstable character of the materials composing the banks and river bottom. That the river is so wide from Ray's Creek, above Augusta, to the foot of Half Guinea Bar, is due to the unstable nature of the banks. In my opinion, the river along this stretch should be allowed to cut its banks in the bights and to lengthen as much as possible, care being taken not to allow cutting to go so far as to produce cut-offs. In no case below Gardner's Bar are works of improvement necessary, except on or just above crossings. On the nine bars mentioned above, works of contraction are necessary, but in no cases should such works extend from that bank which is the "bight side" above the bar, or, in other words, that side upon which is the "point" at the foot of the bar. To illustrate, in the case of Canoe Gut: It should be the intention to force the channel along the left bank. Works of contraction should extend at proper intervals from the right bank to within about 350 feet of a mean line of the left bank. If, to prevent too great erosion of the bank opposite the long jetties, it should be considered necessary to protect the bank, the protection should, in my opinion, consist of short dams extended from the outer ends in 1 or 2 feet of water, up the face and some distance back on the top of the bank. But dams so placed are very liable to be flanked by freshets, as was the case at Blue House Bar. In such cases the river must be prevented, by the construction of short jetties, from deepening the bights above the points. If, however, no danger exists, the bights above should be allowed to deepen. In the case of Canoe Gut, one or two short dams in the form of bank protection would probably be necessary just above the upper end of the sand-bar on the point. On Twiggs', Half Guinea, and Flowery Gap bars such bank protection would be unnecessary. It will be seen from nearly every detail of river crossings that the channel line crossing the bar is in the form of a reversed curve. This I do not believe to be the natural condition. It results rather from the alternating high and low water. Deep water in the upward continuation of the lower bight is doubtless caused by freshets or ordinary high water. The deepest water above the bar is in a less pronounced bight upon the opposite side of the river. Continued low water deepens the water of this bight, and fills the upper end of the bight opposite and below. High water again opens the channel in the bight below and fills that in the bight above. At Canoe Gut the channel formed by high water is upon the right side, while the low-water channel is upon the left. A crossing is necessary between the two channels. This crossing is made, as is always the case except as the result of continued low water, in the form of a reversed curve. As the water lowers, the reversed curve gradually assumes the form of a straight line and a simple curve. Any attempt to force the channel from one bight to the other across the bar, in the form of a reversed curve, for all stages of water, will result in partial or total failure. In all cases the direction of the channel should depart as much as possible from a reversed curve.

In improving Canoe Gut and Twiggs' bars the channel should in each case follow closely the left bank across the bar, beginning the turn to the left as soon as possible. At Half Guinea Bar and Flowery Gap, the channel should keep as closely as possible to the right.

In general, the river should not be allowed to shorten by forming cut-offs. The slope and current would be too much increased. Better conditions for navigation are met with in rivers of little slope and weak currents. Break-overs or guts, which tend to produce cut-offs or which divert large quantities of water at the expense of the channel below should be stopped. The larger break-overs need obstructions, the

nucleus of which should be piles. Less important guts might be effectually stopped by felling trees into their beds. In places, as at Bailey's Point and Hog Nose Point, where caving banks are liable soon to produce cut-offs, the river banks should be carefully revetted. Revetments of brush and stone would alone hold the bank at the two places mentioned. Bank protection similar to that used on the river in 1889, of fascines and stone, would cost from $1.25 to $1.75 per square yard, depending upon locations. Such protection extending from a proper distance below low water, well up over the face and top of the bank, would cost at Bailey's Point about $6 per running foot, and at Hog Nose about $8. Shore protection in form of short jetties would be a source of danger rather than of benefit. The river at low water would run along their ends, while at high water the direction of the current would be parrellel to the dams and across the bank. That the river has not already cut across these points is doubtless due to the fact that the trees covering the point are small and close together. Enough of the larger trees should also be lopped from time to time to encourage a dense growth of smaller trees and brush. At other places on the river, where a caving bank is separated from the channel at some distance below, by only 400 or 500 feet, the caving should be arrested, if possible to do so without too great an expenditure of money. It is quite likely that by lopping the timber on the banks in a proper manner, for a width of from 50 to 100 feet, the caving of the banks could be stopped. The timber of all sizes should be lopped by cutting partially through the trunks from the upper side at about 4 feet above the ground, and the trees pulled down so as to lie with their trunks parallel to the low-water channel, and the tops down the stream. The trees nearer the edge of the bank should be inclined somewhat toward the channel and those further back somewhat away from it. In places where the growth on the banks is not sufficient to cover it, some kinds of quick-growing bushes, native to the river valley, could be encouraged to grow.

COMMERCE.

It was my intention to obtain complete statistics regarding the existing commerce which is tributary, or which may be made tributary to the Savannah River. In 1889 there were plying upon the river four boats. Mr. John Lawton, the manager of two of these boats, has refused to give information regarding the business done by them. The Georgia Chemical Works of Augusta, the owner of a third boat, has neglected to give information regarding the work done by their boat. A letter directed to the president of the Board of Trade at Augusta, regarding exports and imports, has failed to elicit a reply. To further complicate matters, the Agricultural Commission of the State of Georgia could give no information regarding the agricultural resources of the bordering counties.

That portion of the public which is most interested in the improvement of the Savannah River is comprised by the city of Augusta and by the country immediately tributary to it, and yet their representatives neglect to furnish us with the necessary information. The private individuals who have practically a monopoly of the freighting on those parts of the river most needing improvement, not only neglect but refuse to give the proper information, although exactly such information and in the form desired is known, beyond a reasonable doubt, to be in their possession. In the absence of exact figures, estimates from the most reliable sources have been taken. The freighting done by the Georgia Chemical Works has been estimated from their tonnage and schedule, while that done by the boats managed by Mr. Lawton has been estimated mainly from his report to a special agent of the Eleventh census. I say "estimated" because the report made for the census was not in such a form as to show the amount of business done by them and consequently the commercial value of the river.

During the year 1889 four boats plied upon the Savannah River. The following table shows the capacity of each boat and the length of time engaged in river traffic during the year:

	Name.	Over all.		Draught when fully loaded.	Approximate gross tonnage.	Ordinary maximum load.	Months engaged in regular trips during 1889.
		Length.	Width.				
		Feet.	*Feet.*	*Feet.*	*Tons.*	*Tons.*	
1	Katie	140	40	5.5	700	200	12
2	Advance	156	40	4.5	740	225	3¾
3	Progress	156	40	4.5	740	225	6
4	Ethel	140	36	4.5	535	175	12

Of the above boats the first is owned by Mr. John Lawton, and made regular weekly round trips during the year between Savannah and Augusta. The second boat was leased by Mr. Lawton and ran in connection with the *Katie*, making regular weekly trips during the last 3½ months of the year. The *Progress* was purchased by the Georgia Chemical Works of Augusta and run during the last half of the year, making a round trip each week between Augusta and Bull River, South Carolina, via Savannah. The *Ethel* made semi-weekly round trips during the year between Savannah and Cohen's Bluff. The *Progress* was doing a private, while the other boats were doing a public business. Besides the freights carried upon the various boats, the river valley affords logs, hewn and sawn timber, spars, and cord-wood. The timber is rafted down the river. A large portion of the cord-wood is lightered to Savannah, while the remainder is burned by the river boats. The hard wood sawn and the staves and shingles split along the river are shipped to Savannah by boats. The tonnage carried by the river boats between Savannah and Augusta amounted for the year 1889 to an aggregate of about 35,600 tons, worth about $2,140,000. The tonnage of logs, timber, and cord-wood rafted and lightered to Savannah, including the wood burned by the river boats during the year, was about 22,400 tons, valued at about $79,000. The total commerce of the river was then about 58,000 tons, valued at about $2,219,000. The following table shows roughly where these freights were handled and of what they consisted:

Articles.	Rough freights.		Local freights.		Rafted and lightered.		Total.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
Cotton	1,643	$307,170	3,122	$593,180	.....	.....	4,765	$890,350
Grain and mill products	423	9,312	763	15,008	.....	.....	1,186	24,320
Naval stores	2,077	59,395	7,000	150,625	.....	.....	9,077	21,029
Fertilizers, manufactured and raw	4,100	33,800	2,954	53,190	.....	.....	7,054	86,990
Lumber and timber	.....	.....	195	2,000	6,700	$42,400	6,896	44,400
Sugar	1,500	180,000	78	9,320	.....	.....	1,578	189,320
Miscellaneous	2,500	160,000	9,244	577,000	.....	.....	11,744	737,000
Cord-wood	1,000	1,875	3,560	5,230	12,140	29,495	15,700	36,600

Aggregate tonnage of river, 58,000 tons; value of same, $2,219,000.

Besides carrying about 35,600 tons of freight, the various boats carried during the year about 18,000 passengers. Many of the passengers were carried free with their freights. A great majority of all persons carried were classed as deck passengers. In Mr. Lawton's report to the census agent he estimated the receipts to average one-half cent per mile per passenger. The receipts from passengers are estimated upon this basis. The total receipts from the 18,000 passengers carried are estimated at $6,600, while the cash receipts from the freights carried by the four boats during the year 1889 were about $55,473. The total gross receipts from the four boats were about $62,073. The to talexpenses of all the boats during the year were about $54,550, leaving net earnings of about $7,523, or an average net earning of about $225 per month per boat. The total passenger miles for the year were about 1,320,000, and the total number of ton miles was about 4,431,780. The average expense incurred by the boats for each ton of freight handled (assuming that the cost of carrying passengers is one-half the passenger receipts, which is very nearly the case) was about $1.44, while the average tariff collected by the boats was about $1.56 per ton. The total average cost of running the four river boats was about $0.0115 per ton per mile.

By river, as by railroad, the freight tariff per ton varies greatly with the class of goods. Merchandise, particularly dry goods, is classed high, while heavier articles, not perishable, are carried quite cheaply. While railroads charge more for long than for short hauls, the river boats charge the same rate on local freights for all distances. The boats would take a ton of guano from Savannah and deliver the same either in Purysburg or Augusta for $1.50. The Charleston and Savannah Railway would deliver an equal amount at Hardeeville, 3 miles from Purysburg, for about $1.70, while the Central Railway would carry it from Savannah to Augusta for about $2.50. Direct competition between the river and the railroads exists only on through freights between Savannah and Augusta. The river boats have adopted a tariff schedule on through freights and a somewhat lower one on local freights. The railroads, however, have entered into competition on through freights by adopting a schedule much below their local tariffs. As an example of this the Central Railway will carry cotton from Augusta to Savannah, through McBean station, for $1.25 per bale, while the local tariff from McBean, 20 miles below Augusta, to Savannah is $1.55 per bale.

Comparative local tariffs.

Locality.	Cotton: rate per bale.			Fertilizers: rate per ton, car lots.			Rosin: per package.*		Turpentine: per package.*	
	By railroad.		By boat to Augusta or to Savannah.	By railroad.		By boat from Augusta or from Savannah.	By railroad to Savannah.	By boat to Savannah.	By railroad to Savannah.	By boat to Savannah.
	To Augusta.	To Savannah.		From Augusta.	From Savannah.					
Richmond, Ga....	$0.75	$1.55	$0.80	$0.96	$2.40	$1.50	$0.35	$0.25	$0.75	$0.30
Aiken, S. C.....	.60	.....	.80	1.10	2.50	1.50	.....	.....	.....	.....
Burke, Ga.....	1.00	1.45	.80	1.26	1.98	1.50	.34	.15	.63	.20
Barnwell, S. C.....	.95	.....	.80	1.30	3.00	1.50	.42	.15	.90	.20
Screven, Ga.....	1.25	1.25	.80	1.68	1.56	1.50	.27	.15	.36	.20
Hampton, S. C	1.00	1.15	.80	1.70	1.56	1.50	.25	.15	.30	.20
Effingham, Ga....	1.50	1.00	.80	1.98	1.26	1.50	.23	.15	.31	.20

* Through freights.

It will be seen that the competition is about on an even basis from Richmond County, Ga., and Aiken County, S. C., to Augusta, on cotton. Toward Savannah, however, the rates on cotton are in favor of river transportation. The railroads however can carry fertilizers in quantities under favorable competition from Augusta into Richmond and Burk counties in Georgia, and into Aiken and Barnwell counties in South Carolina, and from Savannah into Effingham County, Ga., and into the lower districts of Hampton County, S. C. On naval stores however the river again gives a decided advantage on both through and local freights from all points. The exports from the river valley are mainly cotton and naval stores, while the imports are fertilizers and manufactured merchandise. Corn, oats, peas, potatoes, and sorghum are raised in the valley but not in sufficient quantities to become articles of export. Some years since considerable corn was shipped from Richmond and Aiken counties to Augusta. At present very little corn from those counties ever reach the market. Of the resources of the river valley it can reasonably be expected that the annual shipments by water of wood, timber, and naval stores will remain about constant, or at most will not increase by more than 5 to 10 per cent. per year. The shipments of cotton by river might be much increased by running more boats and by having proper facilities for handling and storing the crop. Most of the cotton landings are upon the low banks of the river which are overflowed by freshets. Cotton can not be delivered at the landings until the boats are due. Long hauls by wagon are thus prevented, except to such landings as are above freshet lines. With an increase of cotton shipments by boat would come increased shipments of fertilizers through the same channel. The ratio of increase would, however, not remain the same. The difference in the freights would be more in favor of river transportation on cotton than on fertilizers. For instance, points midway between the railroad and the river in Burke County, Ga., would ship cotton by boat to Savannah and get fertilizers by rail from Augusta. At the present time the boats carry back about one ton of fertilizers for every ton of cotton brought out. Manufactured goods will not be carried to local points to a much greater extent than at present, until better facilities are offered at way landings for storing and protecting the goods. Except at a few places, no freight-houses are at present provided. Of through freights, the amount could be increased to many times the present tonnage.

I have prepared estimates of the amount of cotton grown during the year 1889 upon the country tributary to the Savannah River. I find that for the State of South Carolina the yield of cotton in 1889 as returned by the Commissioner of Agriculture for that State shows an increase of 22 per cent. over that of 1879 as returned by the Tenth Census. In the absence of all definite information, I have assumed the same ratio of increase for the State of Georgia. In estimating the portion of each bordering county which is tributary to the river I have assumed, for equal freight rates, that the river would draw all cotton up to a line midway between the river and the railroad, and that for every 10 cents per bale difference in freight rates in favor of river boats the boats would draw cotton from 1 mile beyond the middle line. It is not expected that this condition can be reached until the river boats give a service equal to that offered by railroads. In the estimates upon the cotton production along the river I have excluded the lowlands bordering the river upon which no cotton is grown and considered only percentages of the remainder.

Estimated cotton crop of 1889.

Localities.	Crop of 1879.*	122 per cent. of crop of 1879 assumed to be crop of 1889.	Crop of 1889.†	Country tributary to Savannah River.	
				Percentage.	Estimated crop of 1889.
	Bales.	*Bales.*	*Bales.*		*Bales.*
Richmond, Ga	2,742	3,345	.....	.00	.....
Burke, Ga	29,172	35,589	.....	.30	10,677
Screven, Ga	8,166	9,982	.....	.60	5,989
Effingham, Ga	686	837	.....	.40	335
Aiken, S. C	.....	.....	14,290	.02	286
Barnwell, S. C	.....	.....	48,622	.10	4,862
Hampton, S. C	.....	.....	8,275	.40	3,310
Total	.....	.....	.....	.....	25,459

* Report of Tenth Census. † As reported by the Commissioner of Agriculture.

The total amount of local cotton carried by the river boats during 1889, was only about 12,759 bales, or only about 50 per cent. of the estimated crop for the country reasonably tributary to the Savannah River. Of this amount the steam-boat records show that about 6,000 bales came from above Cohen's Bluff, while the remainder, about 6,759 bales, was loaded from Cohen's Bluff and below. My estimates given above show about 18,000 bales to be tributary to the river above Cohen's Bluff and about 7,459 bales from Cohen's Bluff down. Four boats per week from Cohen's Bluff to Savannah carried about 90 per cent. of the estimated crop of the country tributary to the river, while two boats per week between Augusta and Cohen's Bluff carried only about 33 per cent. of the crop of that section. Upon the upper end of the river, were the proper facilities offered at way landings for the protection and handling of the cotton; were a sufficient number of boats put on the river, and the river improved sufficiently to insure rapid and unimpeded transportation of the crop, a much greater per cent. of the total crop would be handled by the river. Boats of only sufficient capacity for carrying the present average freights of the river can not carry all of the cotton offered without delay. Under the present relation between the producer and factor the mode of transportation offering the least delay is adopted regardless of expense. A few years of prosperity will see the cotton planters independent of any particular factor, and able to hold his cotton instead of having it forced into the market as soon as made by men who hold their notes. If the commerce of the river valley combined with that of the city of Augusta would give a service above Cohen's Bluff as good as that below, I have no doubt that within a short time the river boats would be able to gather each year between Cohen's Bluff and Augusta 15,000 bales of cotton.

For a few years previous to 1888 neither the railroads nor the river boats appeared to have discriminated in favor of through freights. The following table shows the effect of competition on through freights between Augusta and Savannah:

Through freights on cotton—Augusta to Savannah.

Year.	Freight by—		Boats plying between Augusta and Savannah carrying cotton.	Competing lines of boats.
	Railroad.	Boat.		
	Bale.	*Bale.*	*No.*	*No.*
1885	$1.60	$1.05	2	2
1886	1.60	1.05	1	1
1887	1.60	1.05	1	1
1888	1.00	.80	4	3
1889	1.25	1.00	2	1

The monopoly in the boating interests and the high rates by rail previous to 1888 caused the building of three new boats, which were put on the river in 1888. The Central Railway then reduced their rates on cotton to practically those of the river boats. To meet this, the boats put their through rate down to their local rate, cutting the rail rate by 20 per cent. This sharp competition practically drove from the river the three boats mentioned above. Both competitors then put up their rates 25

per cent., the boats still remaining the lower by 20 per cent. The Central Railway would doubtless resume its local schedule of $1.60 per bale were it not for the fact that two of the three boats placed upon the river in 1888 are "still in the field."

Commercially the Savannah River is worth more to the city of Augusta than to the planters along the river valley. The difference in through freights between Savannah and Augusta in favor of river transportation would save thousands of dollars annually to the city. Not only is the difference great upon the large shipments from one city to the other, but upon the larger shipments between Augusta and American points above Baltimore and to all European ports. The following table shows a comparison between rail and steamboat rates on through freights between Savannah and Augusta:

Rates.	Per 100 pounds.						Per package.	
	Classes according to railway schedule.					Cotton.	Rosin.	Spirits of turpentine.
	4.	6.	B.	C.	R.	J.		
By railroad	$0.40	$0.25	$0.21	$0.12½	$0.17	$0.25	$0.35	$0.76
By steam-boat	.25	.16	.15	.10	.08	20	25	30

Upon the classes not mentioned the freights are practically the same by both rail and river except for special lots upon which the river offers special rates. The classes mentioned above, however, cover the bulk of the present freights. In general, the boats carry groceries and heavier manufactured goods at about 66 per cent. of rail rates. It might be especially noted that canned goods are carried to Augusta at 37 per cent. of the corresponding railroad rates, while sirups are carried at 50 per cent. From Boston, New York, and Philadelphia goods are handled by the river boats in connection with ocean steamers, at rates lower than by rail. Groceries and heavier manufactured goods are delivered at Augusta at about 80 per cent. of "all rail" rates. On dry goods and on all other articles, the river boats offer to cut rail rates on special lots.

The volume of Augusta's important exports has not been determined. I have no data upon which to base even an approximate estimate. Information which might have been furnished by the Augusta board of trade has been withheld. Upon the principal article of export, viz, cotton, I have been able to obtain a reasonably good estimate. Of the cotton crop of 1889 about 201,000 bales reached Augusta. Of this quantity about 80,000 bales are reserved to be manufactured during the year in and about the city, and about 121,000 bales shipped to northern and European ports. Of this 121,000 bales, about 73,000 bales are shipped *via* Savannah and about 48,000 bales *via* the ports of Port Royal, Charleston, Wilmington, and Norfolk. Of the 73,000 bales going to Savannah, the river boats carried only about 7,000 bales. In the production and exports of cotton, the crop of 1889 was about the same as for the previous year; about 12 per cent. above the mean for the last ten years, and about 22 per cent. above that for the census year of 1879. That three-fifths of all the cotton exported from Augusta now goes *via* Savannah, and that the other two-fifths is divided among three ports, shows that better railroad rates can be obtained via this port. The difference between rail and water rates, upon an equal basis as to compressing, insurance, etc., would show a net gain to Augusta and to the planters on export cotton alone of about $30,000 annually. But there are annually produced fully 300,000 bales of cotton in the territory reasonably tributary to Augusta. Were the river improved sufficiently to allow a good unobstructed service by boats, the difference in through freights would largely increase the cotton shipments from Augusta.

Some idea of the business now done by the city of Augusta may be obtained from the following comparative statement:

Year.	Manufacturing establishments.	Hands employed.	Value of manufactured product.	Value of taxable property in the city.	Volume of trade.
1879	86	1,959	$3,400,780	.....	.....
1885	250	7,182	10,272,284	$16,556,746	.....
1887	.....	.....	.....	.....	$59,505,000
1888	318	7,890	16,499,767	20,175,276	63,556,000

EFFINGHAM CO. GA.

S.C.

44
43
Chairmaker Pt. 41
42 Little Boykin Bar
Big Boykin Bar
Boatmaker Pt.
40 Zacharias Round
Frying Pan L dg 39 Frying Pan Point
Gaffney's Landing
Lodes Creek
Berry's Landing 38
Seine's Landing
Ebenezer Reach
37
36
Ebenezer Creek 35
Ebenezer Landing
34

S.C.

Kings I.
Cross Tides
3
Front River
Back River
Bacons Bar 2
Pennyworth I.
1
Hutchinsons I.
0
CITY OF SAVANNAH.
Screvens Ferry

Eng 90

Height of Rise

B.M. No 3 = 30.62

Little Boykin Bar

Big Boykin Bar

No

Drakies Point Cut Off

Middle River

5

B.M. 10.36

Cross Tides

1 0 = 0.2

Miles

CITY OF SAVANNAH

30' 20' 10' 0' 10' 20' 30' 40' 50' 60' 70' 80' 90'

Upon the basis of the present exports and imports and of the freight rates existing at the present time, I give the differences in favor of transportation by water between Savannah and Augusta, for one year, on a few selected commodities:

Commodity.	Export or import.	Unit.	Number of units.	Difference in freight.	
				In favor of boat, per unit.	Total in favor of boats.
Cotton	Export	Bale	120,000	$0.25	$30,000
Fertilizers	Import	Ton	30,000	.75	22,500
Sugar	do	do	1,500	1.80	2,700
Naval stores	Export	do	2,000	.50	1,000

It does not seem improbable that upon the basis of the present production and freight rates a difference of $80,000 to $100,000 annually in freight tariffs alone would exist in favor of water transportation. Were the river improved sufficiently to make water transportation certain and safe at all seasons of the year by boats of 4½ feet draught carrying a safe net load of 250 tons, the placing of a sufficient number of boats upon the river to carry any considerable portion of the through commerce would doubtless secure to Augusta a great reduction in through-freight tariffs. It is not improbable that the Savannah River now enters into competition on 100,000 tons of through freight, which at the regular rates she would carry for $75,000 less than the present railroad rates. Four boats, of a safe net capacity of 250 tons each, would carry this bulk of freight during the year. But the demand for transportation is not constant during the year. It is quite likely that in order to carry the through freights as fast as they are presented, double that number of boats would be required. The boats would then average to carry goods only one way on each round trip. These boats can be run on through freights alone, each making fifty round trips per year, including delays for repairs, etc., at an expense of $2,000 per month. The total expense of carrying Augusta's through commerce by boat (upon the above supposition as to quantities) would be about $192,000 per year. This is only 80 per cent. of the amount now paid annually to the railroads for carrying her cotton to the sea and bringing back the fertilizers with which to produce another crop. It is reasonable to suppose that the placing of a sufficient number of boats upon the river to carry all commerce between Augusta and the sea would cause the railroads to meet, and perhaps to cut, the water rates. Even were the water rates met by the railroads the boats could run to full capacity during perhaps four or five months of the year. Even were the rates placed so low by the railroads as to compel the boats to tie up, the eight boats could be kept in running order at an annual expense, including repairs, maintenance, insurance, and first cost, at a small percentage of the annual saving to the people of Augusta and to the surrounding country. The presence of such boats, ready for instant use upon an improved river, would serve to keep freight rates within the proper limit.

Very respectfully, your obedient servant,

GEO. W. BROWN,
Assistant Engineer.

Lieut. O. M. CARTER,
Corps of Engineers, U. S. A.

REPORT OF MR. F. C. ARMSTRONG, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., June 30, 1890.

SIR: The snag-boat *Toccoa* was rebuilt at Abbeville, Ga., by M. A. Sweeney & Bro., of Jeffersonville, Ind. Her dimensions are 130 feet by 30 feet by 5 feet—stern-wheel. There are two steam capstans, and a shear frame, with whips, double, triple, and quadruple blocks for 2-inch lines. The boat was outfitted at Savannah and left September 4, 1889, for Augusta, making the 202 miles in thirty-eight running hours, an average of 5¼ miles per hour.

The amount to be devoted to snag-work on the Savannah River was limited, and to expend it to the best advantage operations were confined to King's Creek (113⅓–115⅓) and from Canoe Gut (194) to Port Royal and Augusta Railway Bridge (198).

The work was delayed by the usual accidents incidental to a new plant, packing blown out; fire front rebuilt; gear wheel of capstan broke; hooks on tackle blocks broke; tackle blocks broke, etc. The rope proved to be of inferior quality—hard and stiff—and was a constant source of trouble, breaking blocks and wasting time in overhauling by steam. The tackle blocks were ordered with shackles, but they only arrived the day before the boat left Savannah, so was obliged to accept them.

The following is a summary of work done:

Locality of work.	Distance above Savannah.	Snags over 6 inches.	Snags under 6 inches.	Stumps.	Overhanging trees over 6 inches.	Overhanging trees under 6 inches.	Trees girdled.	Logs cut upon bank.	Explosives used (pounds).
	Miles.								
Port Royal and Augusta Railway Bridge	198	28	4	1	.....	.....	.....	.....	.....
Blue House Bar	197½	7	6	.....	.....	.....	.....	.....	.....
Miller's Cut-off	196	10	5	.....	1	.....	.....	.....	.....
Eve's Bar	195	19	13	2	2	.....	.....	.....	.....
Canoe Gut	194	.....	3	.....	2	.....	.....	.....	.....
Joe Wood's Bar	179½	23	.....	.....	1	.....	.....	.....	.....
Boat-yard	174½	18	7	.....	2	3	.....	.....	.....
Wring Jaw Point	121¼	4	1	1	.....	.....	.....	.....	.....
Fat Meat Point	119	1	.....	.....	.....	.....	.....	.....	.....
Burton's Ferry	116½	7	.....	.....	.....	.....	.....	.....	.....
Mills' Landing	112	3	.....	.....	.....	.....	.....	.....	.....
King's Creek	113½ to 115½	57	18	6	83	25	5	5	12
Total	.....	177	57	10	91	28	5	5	12

Date.	Total days worked.	Days removing snags.	Explosives used (pounds).	Snags over 6 inches.	Snags under 6 inches.	Stumps.	Overhanging trees over 6 inches.	Overhanging trees under 6 inches.	Trees girdled.	Logs on bank cut up.
1889.										
September	23	16	.....	52	17	1	3	.....	.....	.....
October	27	24	12	87	37	9	85	25	5	5
November	10	8	.....	38	3	.....	3	3	.....	.....
Total	60	48	12	177	57	10	91	28	5	5

The river was at a good working stage, 2 feet to 5 feet above low water. The "snags over 6 inches" were generally some 12 inches to 60 inches in diameter; only the most troublesome snags were taken, and these in a majority of instances were cottonwoods averaging 4 feet.

It would require the continuous services of the *Toccoa* one year, with the varying stages of water, to remove the obstructions I consider necessary, and another year to remove those "troublesome but not dangerous."

I give localities where more or less work is necessary; a portion I have seen at low water, but for a large proportion I am dependent on information derived from others. This is the work that will require a year to remove.

Locality.	Distance above Savannah.	Locality.	Distance above Savannah.
	Miles.		*Miles.*
Glover's Point	19	Below Johnson's Landing	122
Bridge Point	27	Above and below Big Randall Point	125 to 126
Hickory Bend Point	28	Little Randall Point	127
Flat Ditch Point	23½	Mouth of Lower Three Run Creek	128
Bay Bush	31	Catfish Hole Point to below Devil's Elbow	135 to 136
Big Keiffer Point	32½	Confederate Obstructions	137
Bowlmaker Point	41½	Jack of Clubs Point	138
Big Boykin Bar	42½	Steel Creek Landing	142
Sister Cut	49½	Hancock's Landing	152½
	50	Above and below Cox's Point	154
Trowell's Landing	52	Moccasin Gap, and below	155¼ to 154¾
Hog Nose Point, and above	53	Haynes' Cut	158
Below Stokes Landing	54¾	Cidar House Round	159¼
Nigger Wench Lake	56¾	Demeries' Ferry	161
	58½	Shell Bluff	162
Above and below	64	Shore High House Round, and below	165½ to 166
Jacob Jump Point	71		168
Poor Robin Landing	80½	Buzzard's Bar	168½
Thompson's Cow Fold Point	88		169
Cat Finger Cut	89½	Above Gray's Point	170
Friday's Dream Point	92	Hog Crawl Round	171
Brier Creek Suck, lower	93¼	Lower Silver Bluff	173½
Brier Creek Suck, upper	94¼	Boat Yard	174¼
Whirligig	95	Above Upper Silver Bluff	175½
	96¼	Lower Stingy Venus	177½
Saucy Boy Point	98	Stingy Venus	179
Wild Cat Point	98½	Hungry Swamp	180½
Cook's Field	100	Belmont Lower Landing	181½
Poke Patch Bar	102	Ten Mile Bar	182½
Dick's Lookout Point	104	Bradford Point	185
Head of Red Bluff Point	106¾	Half Guinea Bar	187
Black's Landing	108	Twiggs' Bar	188
Green Log Point	110	Mason's Landing	191½
King Creek	113½ to 115¼	Eve's Bar	195
	117	Bridge, Port Royal and Augusta Railway	198
Fat Meat Point	119		
Wring Jaw Point	121		

The worst section is from Buzzard's Bar (168) to Twiggs' Bar (188) and should be worked first. It will take the snag-boat three months of good working stage to cover this.

Very respectfully, your obedient servant,

F. C. ARMSTRONG,
Assistant Engineer.

First Lieut. O. M. CARTER,
Corps of Engineers, U. S. Army.

O 3.

IMPROVEMENT OF SAVANNAH RIVER ABOVE AUGUSTA, GEORGIA.

The Savannah River is formed by the junction of the Tugaloo and Keowee rivers, and flows in a southeasterly direction to the sea. Above the city of Augusta the river is navigable only by pole-boats.

A detailed description of this river is given in my report of the preliminary examination and survey, printed as House Ex. Doc. No. 213, Fifty-first Congress, first session.

For a special history of past work, see page 1032, Annual Report Chief of Engineers for 1888.

ORIGINAL CONDITION.

The Savannah River above the city of Augusta has a very steep slope, and the obstacles to navigation are not only numerous and ex-

tensive but at places quite dangerous. They consist of rocky ledges, isolated bowlders, and bars of sand and gravel with minimum low-water depths of less than 1 foot.

PLAN OF IMPROVEMENT.

The plan of improvement, as outlined in my report of January 31, 1890, provides for the establishment between Petersburg and The Locks of a down-stream channel, 12 to 25 feet in width, and navigable during ordinary summer low water (or from nine to ten months of each year), for pole-boats drawing 2 feet, and of an up-stream channel navigable under the same conditions for pole-boats drawing 1.3 feet of water.

This is to be obtained by (1) removing logs and overhanging trees; (2) excavating rock, sand, or gravel, and with excavated material raising crests of ledges; (3) constructing training-walls to increase flow of water through sluices.

The cost of the improvement is estimated at $23,000, provided the money is all made available at once, or at $33,000, if supplied in smaller amounts.

SUMMARY OF OPERATIONS PRIOR TO JULY 1, 1889.

In 1881 work was begun at the rapids near Steven's Creek Falls, about 8 miles above Augusta. Since then operations have been carried on between that point and Ring Jaw, 34 miles above Augusta. The work done consisted in the removal of solid ledges of rock, bowlders, and gravel, and in the construction of wing-dams for contracting the waterway. These dams were built of brush-mattresses loaded with riprap stone, and in some instances of stone alone. In the execution of this work there were removed 4,231 cubic yards of rock, chiefly by blasting, 37 cubic yards of loose bowlders, and 62 cubic yards of gravel.

In the construction of the brush-wing-dams, there were employed 6,670 square yards of mattresses and 1,726 cubic yards of riprap stone; in the construction of the stone wing-dams, 2,458 cubic yards of riprap stone were employed. All work was done by contract.

Up to July 1, 1889, the total expenditures for the work, including outstanding liabilities, amounted to $38,346.98.

Operations were suspended in August, 1883, since which time no work of construction has been done.

CONDITION OF WORK, JUNE 30, 1890.

For a detailed description of the condition of this stream, I respectfully refer to my report of the survey and examination previously referred to.

COMMERCE AND NAVIGATION.

Traffic on this river is carried on entirely by pole-boats which are, in general, about 85 feet long, 7 feet wide and drawing from 20 to 22 inches, when fully loaded. They carry a load of about 12 or 13 tons down-stream and 6 to 8 tons up-stream. Cotton is the principal down-stream freight. Supplies, farming implements, fertilizers etc., constitute the up-stream loads.

The value of the present annual commerce is about $300,000. The total freight receipts during the year 1889 were between $25,000 and $30,000. With improved pole-boat navigation the commerce would be

increased to about $850,000 a year with freight receipts of $50,000 to $60,000. Steam-boat navigation on this river is impossible without resort to a system of locks and dams which would entail an expenditure not warranted by the present or prospective commercial value of the stream.

MISCELLANEOUS.

A report of the survey and examination of this river, printed as House Ex. Doc. No. 213, Fifty-first Congress, first session, is appended hereto.

Since the work of improvement was commenced, the following appropriations have been made:

By act of Congress approved—	
June 14, 1880	$16,000.00
March 3, 1881	8,000.00
August 2, 1882	15,000.00
Total	39,000.00
The expenditures to June 30, 1890, including all outstanding liabilities, aggregated	39,000.00

The work is located in the collection district of Savannah, Ga.

Savannah is the nearest port of entry. Amount of duties collected in 1889, $58,815.54.

The nearest light-houses are those upon the river below Savannah, and Forts Oglethorpe and Pulaski are the nearest forts.

The sum of $23,000 can be advantageously and economically expended during the year.

Money statement.

July 1, 1889, amount available	$653.02
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	653.02
Amount (estimated) required for completion ef existing project	33,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	23,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

O 4.

IMPROVEMENT OF ROMLEY MARSH, GEORGIA.

Romley Marsh is situated to the southeast of Skiddaway Island, between Wassaw Sound on the north and Ossabaw Sound on the south. The water-route through this marsh forms part of the inland passage between the Savannah River, Georgia, and the St. John's River, Florida.

Operations for improving the channel through this marsh have been carried on in accordance with a project of improvement submitted to the Chief of Engineers by General Gillmore, the officer then in charge, dated November 15, 1880, and printed as Appendix J 19, Annual Report of the Chief of Engineers for 1881.

ORIGINAL CONDITION.

The old route through Romley Marsh is exceedingly crooked and difficult to navigate. In many places the mean low-water depth does not exceed 4 feet. In some places it is not more than 3.5 feet. The mean rise and fall of tide is 7.7 feet.

PLAN OF IMPROVEMENT.

Four routes were suggested in the report of the engineer, known as routes No. 1, No. 2, No. 3, and No. 4, respectively. The best and most desirable route is that numbered 1, the most expensive that numbered 4.

By direction of Congress route No. 4 was selected for improvement. This route is the most easterly of those reported upon. The plan of improvement provides for the opening of a cut between Dead Man's Hammock Creek, which flows through the marsh and empties into Wassaw Sound, near the mouth of Romley Marsh Creek and Wassaw Creek, which empties into Odingsell River near the entrance of the latter into Ossabaw Sound. It was proposed to give the cut a depth of 7 feet at mean low water, with a minimum bottom width of 48 feet. The cost of the improvement was estimated at $38,720. No money was ever expended by the United States in improving Romley Marsh prior to the adoption of the present project. Since then appropriations aggregating $42,108.77 have been made by Congress for the work.

SUMMARY OF OPERATIONS PRIOR TO JULY 1, 1889.

Operations were begun in May, 1883, and carried on intermittingly until September 1, 1885, when operations were suspended on account of lack of funds. On September 3, 1885, operations were resumed by private parties and carried on until April 30, 1886, when work was completed. The cut was dredged to a depth of 7 feet at mean low water, with widths at the bottom of from 40 to 50 feet, and at a marsh level of from 88 to 138 feet.

The total length of the cut is 4,117 feet, of which 3,547 feet are through the marsh, and 570 feet are at the head of Wassaw Creek. In this creek cuts of 300 feet, 1,050 feet, and 250 feet in length were also made at Shoals No. 1, No. 2, and No. 3 respectively. (See map, Report of 1886.)

The execution of the entire work required the removal of 211,562.3 cubic yards of material. Of this amount 99,119.94 cubic yards were removed by private parties, who received as re-imbursement $17,475, appropriated by an act of Congress approved August 5, 1886, and $4,633.77, appropriated by act of Congress of August 11, 1888. Between April 16, and May 10, 1887, a cut was made by private parties in Wassaw Creek across the point of marsh near Shoal No. 1 to obviate the necessity of making the sharp turn formerly existing at that locality.

CONDITION OF WORK JUNE 30, 1890.

An examination of the work was made in June 1890. The banks of the cut are caving in at several points, particularly where the cut crosses the hammock. Here a shoaling of 2 feet has taken place since the work was completed. During the year just closed a shoaling of from .5 of a foot to 1 foot has taken place throughout the cut. The minimum low-water depth is now 4.8 feet.

In Wassaw Creek the depth at one point has diminished about 1.3 feet since dredging was completed, leaving a minimum depth of 5.6 feet.

Had the cut been made in the most suitable place, as recommended by the engineer in charge, it would doubtless have been self-maintaining and of value to commerce. In its present location continual deterioration may be expected.

COMMERCE AND NAVIGATION.

It is impossible to ascertain accurately the amount of commerce which passes through this channel, since it is in an isolated position and boats passing between points north and south of it have other routes available which are often used. Two steamers now use the cut through the marsh, one making semi-weekly trips between Savannah and Fernandina, and the other making daily excursions to Wassaw Island. Vessels are often towed through the channel to avoid rough weather at sea, and many smaller crafts carrying rice, naval stores, and fish, pass through it.

MISCELLANEOUS.

The new cut being much longer and more difficult to navigate in some respects than the old route, vessels use it only when it can not be avoided.

The work is in the collection district of Savannah, Ga. Savannah is the port of entry. Amount of duties collected in 1889, $58,815.54. The nearest light-houses are those upon the Savannah River, and Forts Oglethorpe and Pulaski are the nearest forts.

The following appropriations have been made for this improvement

By act of Congress approved—	
August 2, 1882	$10,000.00
July 5, 1884	10,000.00
August 5, 1886	17,475.00
August 11, 1888	4,633.77
Total by United States	42,108.77
From Georgia and Florida Steam-boat Company	5,000.00
Aggregate	47,108.87

The expenditures to June 30, 1890, including all outstanding liabilities, were $47,108.77, all funds having been exhausted.

No further work is recommended at this locality, and no appropriation is asked for the next fiscal year.

Money statement.

July 1, 1889, amount available	$172.55
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	172.55

O 5.

IMPROVEMENT OF THE ALTAMAHA RIVER, GEORGIA.

The Altamaha River is formed by the junction of the Oconee and Ocmulgee rivers, in the southeastern part of Georgia, and flows in a southeasterly direction to the sea.

A detailed description of this river is given in my report of a recent survey, dated June 12, 1890, which is transmitted herewith.

For a special history of past work see page 1038, Annual Report of the Chief of Engineers for 1889.

ORIGINAL CONDITION.

The chief obstructions to the navigation of the Altamaha River consisted in rock ledges, sand-bars, overhanging trees, snags, and sunken

logs. The rock ledges were confined to the upper portion of the stream, while the other obstructions were found throughout its entire course. The low-water depths at some points did not exceed 1 foot.

PLAN OF IMPROVEMENT.

The plan of improvement outlined in my report of June 12, 1890, provides for the establishment of a navigable steam-boat channel 3 feet deep at ordinary summer low water between the junction of the Oconee and Ocmulgee rivers and the town of Darien.

This is to be accomplished by (1) Removing rock shoals and sand-bars; (2) building deflecting dikes and closing incipient cut-offs; (3) removing snags and logs from the channel and overhanging trees from the banks of the stream; (4) revetting caving banks.

The cost of the improvement is estimated at $128,627.50, provided funds are regularly and adequately supplied.

SUMMARY OF OPERATIONS PRIOR TO JULY 1, 1889.

The first appropriation ever made for the Altamaha ($5,000) was expended on a snag-boat, which was built for use upon this river and the Savannah. This boat began to work upon the river on October 1, 1883, and has been employed at intervals since that date, regular work having been impossible on account of insufficiency of funds.

Operations have been carried on between Darien and the junction of the Oconee and Ocmulgee rivers. There have been removed in all 2 piles, 936 snags and logs, and 1,849 overhanging trees.

In 1883 channels 100 feet in width and 4 feet in depth at ordinary low water were opened through the rock ledges at Town Bluff and Piney Bluff by the removal of 319 and 1,480 cubic yards of rock at those points, respectively.

In 1884–'85 a training-wall was built at Beard's Bluff for the improvement of a shoal at that locality, and shore protection was constructed for the protection of caving banks. In the execution of this work 811.2 cubic yards of stone, 428.44 cubic yards of gravel, and 3,545.38 cubic yards of brush fascines were used.

All work, with the exception of that done by the snag-boat, has been done by contract.

Up to July 1, 1889, the total expenditure for the work, including outstanding liabilities, amounted to $53,389.03.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

The repairs to the snag-boat *Toccoa*, built for joint use upon this river and upon the Savannah, were completed.

Active operations during the year were confined to the snag-boat *Toccoa* and consisted in the removal of snags, logs, overhanging trees, etc., from nearly the whole length of the river.

There were removed 170 snags and stumps; 309 overhanging trees were felled, and 10 logs were cut up on the river bank.

The survey of the river, begun during the preceding fiscal year, was completed and a revised project of improvement submitted.

CONDITION OF WORK JUNE 30, 1890.

The river is in fair condition so far as logs and snags are concerned. The training-wall at Beard's Bluff contains a few gaps where it is prob-

able that some work has been torn out by persons connected with the ferry. The point opposite the training-wall has been eroded considerably and needs protection. A detailed description of the present condition of the river is given in my report of June 12, 1890, transmitted herewith, and those localities urgently requiring attention are given in the appended report of my assistant engineer, Mr. F. C. Armstrong.

COMMERCE AND NAVIGATION.

For detailed statement of the commerce and navigation of this river see my report dated June 12, 1890, appended hereto.

MISCELLANEOUS.

Water-gauges were read at Town Bluff and Doctortown until November 1, 1889, and July 1, 1890, respectively, when they were discontinued on account of the exhaustion of funds.

The work is located in the collection district of Brunswick, Ga. Darien is the nearest port of entry. Sapelo Light is the nearest light-house, and Forts Oglethorpe and Pulaski are the nearest forts.

Since the project for improving the Altamaha River was adopted, the following appropriations have been made for the work:

By act of Congress approved—

March 3, 1881	$5,000
August 2, 1882	15,000
July 5, 1884	15,000
August 5, 1886	20,000
August 11, 1888	10,000
Total	65,000

The total expenditures to June 30, 1890, including all outstanding liabilities, were $64,776.59.

Of the appropriation made in 1886, $5,795.40 were allotted and expended by authority to improve Doboy Bar.

It is proposed to expend the funds on hand and any which may become available during the present fiscal year in the removal of obstructions, and in the improvement of the shoal places in the river, according to the revised project of June 12, 1890.

The sum of $45,000 can be economically and advantageously expended during the coming year. No permanent improvement can be effected, as new obstructions, caused by logs and snags, form during every freshet stage. They should, however, diminish in number from year to year. From $3,000 to $5,000 will be required for the annual maintenance of the completed work.

A report of the survey of the river is transmitted herewith, dated June 12, 1890.

Money statement.

July 1, 1889, amount available	$5,815.57
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	5,592.16
July 1, 1890, balance available	223.41
Amount appropriated by act of September 19, 1890	15,000.00
Amount available for fiscal year ending June 30, 1891	15,223.41
Amount (estimated) required for completion of existing project	113,627.50
Amount that can be profitably expended in fiscal year ending June 30, 1892	45,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

SURVEY OF ALTAMAHA RIVER, GEORGIA, WITH PROJECT FOR IMPROVEMENT.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., June 12, 1890.

GENERAL: I have the honor to submit the following report on the recent survey of the Altamaha River together with a project for the improvement of the same:

The Altamaha River is formed by the junction of the Ocmulgee and Oconee rivers in the southeastern part of Georgia and flows in a southeasterly direction to the sea. The distance in a direct line from the forks to the town of Darien, which is situated on the north bank of the river 19 miles from the coast, is 75 miles. Following the river channel the distance is 131 miles, determined by the survey of 1888–'89, made under my direction by Mr. A. S. Cooper, assistant engineer. This distance has formerly been given as 155 miles, but was probably ascertained from the river pilots who invariably overestimate distances.

DRAINAGE AREA.

The valley of the Altamaha, about 3,000 square miles in area, is a low undulating country with a sandy, permeable soil. Probably not more than 20 per cent. of the rainfall of the region finds its way to the river. Its volume is mostly derived from the drainage of the clayey hills of central and north Georgia, brought down by its tributaries. The total area drained by the Altamaha and its tributaries, is about 14,620 square miles.

SLOPE.

The total fall of the river between summer low water at the Forks and mean low water at Darien is 83 feet, making an average slope of 0.633 feet or 7.6 inches per mile. With local exceptions the slope is practically uniform at the rate of 8.44 inches per mile as far down as Fort Barrington, where tidal fluctuations at low river begin to be appreciable. In the tidal reaches the low-water slope is 3.6 inches per mile. Local exceptions to the uniformity of slope occur as follows: At English Eddy the slope is 20.4 inches per mile; at Stooping Gum Cut, 24 inches; Beard's Bluff, 26.4 inches; Alligator Creek, Marrow Bone Bar and Doctortown, each, 12 inches; through the Narrows, a distance of 12 miles, 13.2 inches per mile; at Phinholloway Creek, 33.6 inches per mile.

DISCHARGE.

Gaugings of the river were made in October, 1888, and again at a different stage of water, but at the same places, in October, 1889. The results are shown in the following table:

Date.	Place.	Stage of water.	Area of cross-section. Square feet.	Mean velocity of discharge. Feet per second.	Discharge. Cubic feet per second.
October, 1888	Town Bluff	7.2	8,276.0	2.474	20,476.0
October, 1888	Oberry Bar	4.5	6,060.0	3.351	20,310.0
October, 1889	Town Bluff	0.0	4,289.8	1.12	4,726.8
October, 1889	Oberry Bar	0.0	2,277.0	2.212	5,037.1

These results may be checked by comparison with the joint discharge of the Oconee and Ocmulgee rivers, determined at about the same times, as follows:

In October, 1888, the joint discharge of Ocmulgee and Oconee rivers, one mile above the Forks, gauged during falling river and previous to gaugings at Town Bluff, was 21,303 cubic feet per second; in October, 1889, the joint discharge at low water of these rivers (but omitting the discharge of the Little Ocmulgee) was 4,625 cubic feet per second.

In comparing Town Bluff and Oberry Bar low-water discharges, as given in the above table, it must be remembered that the Ohoopee River adds a considerable volume to the flow between those points.

Owing to the limited number of actual discharge measurements it is impossible to arrive at the mean discharge except by deducing it approximately from the rainfall in the river basin. This, as determined by observations covering about twenty years, is 50 inches per year. In the upper part of the river-basin the soil is clayey, and probably 60 per cent. of the rainfall is carried off by the rivers tributary to the Altamaha. About 20 per cent. will be the proper proportion for the permeable soil of the lower valley. Giving to these percentages weights proportional to the areas to which they apply, the average deduced is 37 per cent. for the whole area, and this gives for the mean discharge of the Altamaha, at its mouth, about 19,000 cubic feet per second.

The low-water discharge is sufficient, if properly controlled and directed, to furnish a low-water navigable channel at least 3 feet in depth and of ample width. This is the depth of channel adopted in the original project for the improvement of the river and is considered sufficient for the present and prospective needs of commerce.

FRESHETS.

The freshets on this river are sometimes of great magnitude. That of August, 1887, was the highest known for many years. The water rose at Town Bluff to a height of 21 feet above summer low water; at Ohoopee White Bluff to 19 feet, and at Fort Barrington to 14 feet. The low swamp lands bordering the river are from 2 to 4 miles wide, and are flooded at stages of from 5 to 10 feet; so the discharge during the above-mentioned freshet must have been enormous. It probably greatly exceeded 100,000 cubic feet per second. Freshets of less magnitude occur during the winter season of nearly every year, the river rising out of its banks and flooding the bottom lands.

WIDTHS.

From the Forks to Stooping Gum Cut the river is from 400 to 500 feet wide. At the latter place it decreases to about 200 feet, part of its volume still flowing through the old river. From here to the Narrows it assumes the original widths; but through the Narrows, for a distance of 12 miles, is reduced to from 200 to 250 feet. Old Soldier Reach has widths of from 600 to 800 feet; Couper's Bar a width of about 500 feet; and Darien River, an average width of 250 feet.

TIDES.

During summer low water, tidal fluctuations are evident as high up as Fort Barrington, 23 miles above Darien. During freshets the tides disappear lower down and the tidal ranges above Darien are altered.

The mean range of tides at Darien is about 7 feet; at Couper's Bar 5.6 feet; at Clark's Bluff, 2.8 feet. These determinations are not accurate, being based on a small number of observations, but are true for the time at which taken, viz, December, 1889.

GENERAL DESCRIPTION OF VALLEY.

The river winds through low bottom lands or swamps bordered on either side by the line of sandy bluffs separating them distinctly from the high land beyond. The soil is a light colored sticky earth containing sand, clay, and silt. Roads through the swamps soon become worked up into a thick mud even in comparatively dry weather. The banks are from 4 to 8 feet high and are easily eroded, except on the surface where protected by the roots of the dense growth of trees, brush, and cypress knees. Where the river winds in close to the bluffs a high bank is found on one side and such banks are usually selected for steamboat or timber landings, since they are not subject to overflow. Rock occurs only in the upper part of the valley. It crops out at Town Bluff, Nayle's Ferry, Red Bluff, Falling Rock Bluff, Piney Bluff, Holl's Shoals, Iron Mine Reach, and Lower Sister's Bluff, all in the first 50 miles from the forks. The rock is a siliceous sandstone, generally soft and friable and easily removed. The bottom lands are heavily timbered with a great variety of trees. The cypress and some of the hard woods, oak, ash, hickory, elm, etc., are quite valuable. Gum trees, sycamore, cottonwood, poplar, and willows are very abundant. Cypress grows along the river banks, in low wet places and in shallow sloughs. The hard woods are found on the higher banks and the willows on every point. On the uplands of the valley the timber is almost exclusively yellow pine. Its products, in the shape of naval stores and lumber, find in the river almost the only means of transportation to the markets on the coast. On the lower tidal portion of the river the swamps give way to marshes; the soil becomes dark, soft, and compressible, and in the riverbed, fine sand. Rice plantations line the river until salt water is reached. The town of Darien occupies the only point of high land that pushes through the marshes to the river bank.

A large portion of the country bordering the river is devoted to farming and the area of farm land increases yearly as the timber is cleared away. Cotton, corn, oats, rice, and potatoes are the principal crops. This subject is more fully treated under the head of commerce, where statistics of acreage and yield are given.

A survey of the Altamaha River made under my direction was begun October 11, 1888, by A. S. Cooper, assistant engineer, and continued until October 31, 1888, when it was suspended to await a more favorable stage of water. The river between the forks and Couper's Bar was covered during this period. In October, 1889, the survey was completed by extending it to Darien, and determining the slope by running a line of levels from the forks to Darien.

The survey was made with the following objects in view:

To note the height, character and condition of the river banks; the size and variety of trees and brush; the length and depth of pools and shoals; the nature of the river bottom; and the location, nature and magnitude of existing obstructions to navigation with a view to determining the methods and probable cost of removing them so as to secure a depth of 3 feet at summer low water.

To determine also the high and low water slopes of the river; to establish permanent bench-marks at intervals along the line; to determine at several points the discharge of the river at various stages; to establish gauge staves and have continuous records of their readings kept.

To plot general maps of the survey on a scale of $\frac{1}{9600}$ and detailed maps of shoals, bars and ledges where works of improvement seem necessary, on a scale of $\frac{1}{1200}$, and a profile showing high and low water lines and the river bottom following the channel line, on a scale of 2 miles to the inch, horizontal, and 12 feet to the inch, vertical.

METHOD OF SURVEYING ADOPTED.

Azimuths were determined by readings of the compass needle attached to the transit. Distances were measured on the stadia rod, and the latter being graduated to feet and tenths, it served also as a leveling rod. The party was quartered on a house-flat and two row-boats were used, one for the transitman, the other for the rodman. A river pilot was employed to give information as to the channel followed by steamers and the local names of bights, points, reaches, bars, shoals, landings, etc., and to act as boatman. The transit being set up where good sights up and down the stream could be obtained, the rodman occupied a station up stream at the water's edge and the boating, distance and elevation were read. As the rodman's boat dropped down, it passed near the shore opposite the transit and the width of the river was read from the rod. Readings were then taken to a station down stream. The transitman in moving to his next station followed the channel, taking soundings at regular intervals and recording them in their relative positions on the stretch in his note book. He also observed and noted heights and character of banks, timber growth and brush bordering the river, logs, snags, and other obstructions. Where insufficient depths were found a line was sounded across the river, and upon greater depths being regained the boat passed on. But if the existence of a bar, shoal or ledge was disclosed, a detailed survey was made as follows:

The transit was set up where it commanded a view of the whole area to be surveyed. Lines of soundings crossing the river were run by one of the boats in which the stadia rod was held facing the transit. Every third or fourth sounding was located by the transitman who read bearing and distance of rod at the instant a sounding was taken, the located soundings being noted as such by the recorder in the boat. Shore-lines and natural features in vicinity were determined by stadia readings and the fall from pool above to pool below accurately determined by leveling. Two permanent bench-marks were established at each place thus surveyed. The general survey was then continued.

Discharge measurements were made as follows: A base line 200 feet long was laid off on the bank parallel to the direction of the current. Perpendiculars at its extremities determined the sections to be used. These sections were carefully sounded, the soundings being located in each section by transit readings from the further extremity of the base, range-poles keeping the boat on the section. Velocities were taken with rod and surface-floats. Times of crossing first section and angles to points of crossing on second section were read at upper transit station. Angles to points of crossing on first section and times of crossing second section were read at lower transit station, the transits being at ends of base line. This method was varied when but one transit was available, by setting up range-poles to mark the sections and moving the transit to a point on the prolongation of the base line, from which angles could be read to the points to be located on both sections. Velocities were determined at points about 50 feet apart and reduced to mean velocities. The mean of the two sections was taken as the discharge section; this was divided by verticals into separate areas, and to each area was applied the mean velocity found therein.

The survey was made for the most part when the river was from 3 to

6 feet above low water and in some places overflowing the banks. Some characteristics which might have been revealed at a lower stage were therefore missed, but all of the places that were troublesome to navigation at low water were known and received especial attention, and, in most instances a detailed survey. It is believed therefore that all essential elements are included and portrayed on the maps, and, where work is required, are sufficiently described in this report. Information derived from previous reports, from personal examination and that gained from persons familiar with the river and the business done thereon has been used, as well as that furnished by the survey.

ORIGINAL CONDITION.

The river was originally much obstructed by sand-bars, rock ledges, snags, logs and overhanging trees, preventing navigation entirely at low water and rendering it dangerous at all stages. At some places low-water depths did not exceed 1.5 to 2 feet and often, where the depth was sufficient, it was unavailable owing to the overhanging trees which kept the boats away from the deepest water.

PAST WORK.

Operations for improving this river have been carried on in accordance with a project submitted to the Chief of Engineers by General Gillmore, the officer then in charge, dated November 27, 1880, and printed as Appendix J 9, Report of Chief of Engineers for 1881. This project provided for the establishment of a low-water channel 3 feet in depth and 80 feet wide from Darien to the forks, by the removal of about 10,500 cubic yards of rock, of old wreck and pile obstructions, of several thousand snags and of about 8,000 cubic yards of material in the vicinity of Darien, by dredging. The cost was originally estimated at $60,000 and again in 1884 at $75,000.

Since the existing project for improving the Altamaha River was adopted the following appropriations have been made for the work:

By act of Congress approved—	
March 3, 1881	$5,000
August 2, 1882	15,000
July 5, 1884	15,000
August 5, 1886	20,000
August 11, 1888	10,000
Total	65,000

Of the appropriation made in 1886, $5,795.40 were allotted and expended by authority for the improvement of Doboy Bar.

The average annual appropriation has, therefore, been about $6,000. It has been sufficient merely to improve the worst bars and ledges and to maintain a plant for the removal of the more dangerous snags and overhanging trees.

For a detailed history of past work improving Altamaha River up to 1888 see Appendix N 5, Report of Chief of Engineers for 1888, page 1038. This work may be summarized as follows:

Examinations and surveys.

Date.	By whom made.	Where made.	Character.	Where reported.
Oct. 1880	Col. Q. A. Gillmore	Forks to Darien	Examination	Appendix J 9, Report Chief of Engineers, 1881, page 1109.
Nov. 1882	Capt. J. C. Post	do	do	Appendix L, Report Chief of Engineers, 1883, page 930.
Nov. 1884	Lieut. F. V. Abbot	Beard's Bluff	Survey	
Dec. 1884	Lieut. T. H. Bailey	Darien to Doboy	do	Appendix N 15, Report Chief of Engineers, 1885, page 1234.
Oct. 1886	Lieut. O. M. Carter	Forks to Doctortown	Examination	
Oct. 1888–'89	Lieut. O. M. Carter	Forks to Darien	Survey	

REMOVAL OF SNAGS.

The snag-boat *Toccoa* was completed in February, 1882. She was paid for in part by the appropriation of $5,000 of March 3, 1881, and in part from the appropriation for the Savannah River, being intended for use on both rivers. In 1887, a light-draught scow with steam-hoisting apparatus was purchased for use on those rivers at a cost of $800. December 11, 1888 a contract was closed with M. A. Sweeney & Bro., of Jeffersonville, Ind., for repairing the *Toccoa* at a cost of $10,000. She was entirely remodeled and fitted with shear frames instead of the old-fashioned A frame, and is now an excellent boat.

Snagging operations.

Date.	Location of work.	Length improved.	Obstructions removed.	
			Snags and logs.	Overhanging trees.
		Mile.		
Oct. 1, 1883, to Feb. 23, 1884	Darien to Ohoopee	55	323	185
Mar. 15, 1885, to June 9, 1885	Ohoopee to Rump's	97	32	433
Mar. 1887	At Hugh's Landing	.....	.....	12
Sept. 8, 1887, to Jan. 14, 1888	Ohoopee to Forks	39	424	998
Sept. 1, 1888, to Nov. 26, 1888	Lake Bluff to Forks	81	157	221
Total prior to	July 1, 1889	.....	936	1,849
Nov. 22, 1889, to Jan. 9, 1890	Phinholloway Creek to Town Bluff	95	171	309
Aggregate	.....	.....	1,107	2,158

Remarks.—There have also been 2 piles and 9 stumps removed, 4 logs cut up and 5 trees deadened.

Rock excavation.

Place.	Date.	Length of cut.	Width of cut.	Cubic yards removed.	Cost per cubic yard.	Resulting depth.
		Feet.	*Feet.*			*Feet.*
Town Bluff *	Sept., 1883	75	100	319	$4.70	4
Piney Bluff *	Oct., 1883	150	100	1,480	4.70	4
Total	.....	.....	.....	1,799	.....	.....

* Some loose rock in cut at present.

Work at Beard's Bluff from December 26, 1884, to July 15, 1885.

Character.	Length.	Width.	Material.					
			Fascines.		Stone.		Gravel.	
			Amount.	Per cubic yard.	Amount.	Per cubic yard.	Amount.	Per cubic yard.
	Feet.	*Feet.*						
Training-wall	1,744.2	15	$2,847.50	$1.17	$681.03	$4.47	$353.40	$0.49
Shore protection	500	18	1,057.88	1.17	130.17	4.47	75.00	49
Total	.....	.....	3,545.38	.....	811.20	.....	428.40	.....

Remarks.—Resulting low-water depth 4 feet. Has shoaled again, due to cutting away of banks, to 2 feet.

PRESENT CONDITION.

The present condition of the river, as disclosed by the recent survey, is as follows (distance from the Forks in miles are shown in parentheses):

The first obstruction below the Forks is the rock ledge at Town Bluff (2). The cut excavated here in 1883 is incumbered with some loose rock which must be cleared away in order to obtain the necessary depth. The axis of the cut makes an angle with the direction of the current and some excavation is needed to straighten the channel.

At Half Moon Bluff ($4\frac{1}{2}$) two islands divide the river channel. The two smaller channels should be closed.

At Red Bluff (9) bowlders obstruct the channel and should be removed.

The cut-off called Guilford's Suck ($12\frac{1}{2}$) should be closed.

At Piney Bluff ($19\frac{1}{2}$) is a rock ledge through which in 1885 a cut was made. This cut needs deepening by the removal of loose rock.

A sand-bar exists at Golden Grove (23), due evidently to a widening of the river and to a cut off forming below. The low-water channel should be contracted and the cut-off closed.

From here to Stooping Gum Cut ($55\frac{1}{2}$) the river is in good condition. At the latter place a large volume of water still flows through the old river and the cut is narrow. The old river should be partially closed in order to divert a greater volume through the cut.

Board's Bluff Bar ($60\frac{1}{2}$) is a sand-bar formed at the mouth of a lagoon called Board's Bluff Lake, which extends parallel to the river for about a mile. In 1884 and 1885 a training-wall 1,744.2 feet long, composed of brush fascines loaded with stone and gravel, was constructed, extending from the spit dividing the lake and the river toward the concave bank and parallel to the opposite shore. The concave bank, about 20 feet high, consisting of coarse sand, easily eroded, was protected for 500 feet in length and from 3 feet below to 10 feet above low water by fascines staked to the bank and loaded with stone covering. The opposite bank is low and covered with willows and gums.

The contraction of the river by the training-wall soon caused an improvement in the channel, and 2 feet were added to the depth even before the completion of the work. Since then, however, the low bank on the convex side has been cut away from 100 to 150 feet, and this widening of the river has caused the bar to re-appear. Now, at summer low water, there is a depth of but 2 feet. The requisite depth can be

regained by building spur-dikes from the convex bank to the original low water shore line. The old training-wall should be repaired, and additional shore protection may be needed.

Marrow Bone Bar (64.2) is apparently caused by a widening of the river, aided perhaps by a cut-off forming just above the bar. The cut-off should be closed and the low-water channel contracted by spur-dikes.

At Oswell's Cut the wreck of the steamer *Tar Heel* lies in the mouth of the old river, and her boilers have rolled off into the channel. They can be avoided by steamers, but are a menace to navigation and should be removed.

At First Water Oak Round (36) a number of snags have caused shoaling. Their removal would probably allow the current to scour away the bar. The low-water channel at Second Water Oak Round (39) should be contracted by spur-dikes to scour away the bar.

Bug's Suck (94) is a cut-off about 200 feet wide, rounding a sharp point with a swift current. It is difficult of navigation for steam-boats and dangerous for rafts. The point is indented on the lower side, leaving a low neck of land about 100 feet wide. A new cut across this neck would straighten the channel and render navigation much easier. Either this or cutting away the point is necessary. The former, though more expensive, would give better results.

Through the Narrows the river is narrow and winding and the current swift, but great depths are found, and it is only necessary to keep it free from snags and logs to render navigation safe. Miller's Lake (101) should be closed.

From the Narrows to Clark's Reach, a distance of 22 miles, the river is in good condition, and no work aside from snagging operations will be needed.

At the lower end of Clark's Reach (119½) the river widens to 800 feet, and a bar is formed on which there is a depth of barely 3 feet at low water and low tide. The range of tide here is about 3 feet. The low-water channel should be contracted by spur-dikes from the convex shore to induce deepening by scour.

Here the river begins to separate into the numerous branches through which it finds its way to the sea. The south branch leads into Buttermilk Sound and thence through Altamaha Sound to the sea. The middle branch, after winding through Old Soldier Reach and Couper River, takes a straight course to the sea through Altamaha Sound. Another outlet is found through Darien River to Doboy and through Doboy Sound to the sea. This latter channel is the route by which vessels reach the sea from Darien. Other channels of minor importance it is unnecessary to mention.

Between Clark's Reach and Darien are several places where sand-bars render the low-water depths entirely inadequate. The first point is at Couper's bar, where the Darien route branches off from the main river. This bar has always been troublesome and is impassable at low water, becoming bare except through a small channel 58 feet wide and from 1 to 2 feet deep.

A narrow cut about 1 mile long was made before any improvement of the river had been instituted by the United States, from a point above to Darien River below the bar, but it has filled up so that it is now dry for half its length at low water, and if re-opened would probably require constant works of maintenance. The bar itself can be improved by the construction of contracting and deflecting works and by some dredging,

at a less cost than the opening of the cut would entail, and such improved channel would be more permanent.

About 1 mile below Couper's Bar another bar occurs at Weeping-Willow Crossing, on which the low-water depth is 1.5 feet. Here some works of contraction, aided by the deflecting dams mentioned above and by dredging, will give the necessary depth.

The entrance to Darien River will need works of improvement similar to those at Couper's Bar, but on a smaller scale; and at several points between the entrance and Darien, 2 miles below, minimum depths of 1.5 to 2 feet at low water are encountered. This portion of the river has a uniform and moderate width, not exceeding 300 feet, and to contract the channel at the points where depths are insufficient would have little if any beneficial effect. The channel should therefore be deepened by dredging, and it is highly probable that the increased volume of water sent through this channel by the deflecting works recommended above will maintain the necessary depth and render the improvement permanent.

There remain to be considered in this general description of the obstructions on this river, those due to snags, logs, and overhanging trees. Improvements caused by the removal of these can never be permanent, since the freshets of every year cut away the banks, undermine the trees, and draw them into the channel, or leave them for a time leaning over the river, where they prevent boats from seeking the deepest water and threaten their upper works. Snags, moreover, often lead to the formation of sand-bars by checking the current and causing the deposit of silt. The river once cleared of the snag accumulations of many years would require the use of a snag-boat for perhaps not more than two or three months during each year.

The following is a tabular statement of the character and location of the obstructions, with the improvements recommended and the estimated cost:

Number of obstruction.	Distance from forks.	Name.	Nature of obstruction.	Length.	Width of river.	Least depth.	Slope (feet per mile.)	Recommendations.	Estimated cost of improvement.
	Miles.			*Ft.*	*Ft.*	*Ft.*			
1 A	2	Town Bluff...	Rock ledge	160	500	3.5	0.7	Existing cut through ledge makes angle with direction of current and should be straightened and slightly deepened by cleaning out loose rock.	$2,500
2	4.3	Half Moon Bluff.	Islands forming lateral channels.	1,000	600	6	0.8	The two minor channels should be closed.	450
3	9	Red Bluff.....	Rocky shoal	500	400	3	0.3	Loose rock in channel should be removed.	400
4	12.5	Guilford's Suck.	Cut-off.....	1,200	400	4.5	0.8	Should be closed	300
5	15	Baldwin's Sign.	....do	1,500	500	4	1	....do.....	400
6 B	19.5	Piney Bluff...	Rock ledge.....	100	600	4	0.8	Loose rock in existing cut should be removed. May require slight deepening.	2,000
7 B2	22.3	Golden Grove Bar.	Sand-bar and cut-off.	600	600	3	0.4	Contract low-water channel with pile and brush spur-dikes. Close cut-off.	1,400
8	55.5	Stooping Gum Cut.	Cut-off.....	2,000	300	6	2	Close old river to throw greater volume through cut.	600

Number of obstruction.	Distance from forks.	Name.	Nature of obstruction.	Length.	Width of river.	Least depth.	Slope (feet per mile.)	Rocommendations.	Estimated cost of improvement.
	Miles.			*Ft.*	*Ft.*	*Ft.*			
9 D	60.5	Board's Bluff.	Sand-bar.....	400	600	1.5	2.2	Construct contracting works of pile and brush spur-dikes; repair old training-wall and extend shore protection.	$7,600
10 C2	64.2	Marrowbone Bar.	....do	200	400	4	1	Contract low-water channel by pile and brush spur-dikes.	1,800
11	71.2	Oswell's Cut..	Steamer boilers in channel.	.....	....	....	....	Should be removed.....	200.00
12	78.5	One mile below Doctortown.	Cut-off.....	800	440	5.8	1.0	Should be closed	400.00
13 E	86	First and Second Water-Oak Rounds.	Sand-bars.....	150	400	5.5	0.8	Snags which cause the shoaling should be removed, and low-water channel contracted by spur-dikes.	1,200.00
14	94	Bug's Suck...	Sharp curve	800	240	7.5	1.6	Point should be cut away to render navigation easy.	1,500.00
15	100.7	Miller's Lake	Cut-off.....	4,000	400	6	0.8	Should be closed	600.00
16 F	119.5	Clark's Reach.	Sand-bar.....	400	800	3	0.3	Construct pile and brush spur-dikes to contract low-water channel.	4,800.00
17 G	127	Couper's Bar.	...do	900	700	1	0.3	Construct deflecting dam partially closing Couper's River and spur-dikes to contract low-water channel; dredging in same.	18,000.00
18	123	Weeping Willow Crossing.	....do	480	480	1.5	0.3	Construct spur-dikes to contract low-water channel; dredging in same.	3,300.00
19	129	Entrance to Darien River.	....do	640	200	1	0.3	Construct deflecting dam partially closing Butler's River and spur-dikes to contract low-water channel; dredging in same.	11,000.00
20	130	Darien River.	Shallow.....	3,000	200	1.5	0.3	Remove by dreding 20,000 cubic yards of material.	4,000.00
Total									61,850.00
For improvements which may be rendered necessary by formation of shoals due to changing the regimen and slope of river, and removing obstructions not developed by the survey									15,000.00
Removal of 6,000 snags at $5									30,000.00
Removal of 5,000 overhanging trees at $1									5,000.00
Total									111,850.00
Engineering and contingencies, 15 per cent									16,777.05
Aggregate									128,627.05

NOTE.—Letters refer to detailed surveys.

This estimate is based upon the supposition that the work will be carried forward without interruption and completed in about three years; that is, that about $45,000 becomes available each year during that period. Smaller or irregularly made appropriations would greatly increase the cost and would simply permit the removal of the worst snags without any valuable permanent improvement.

Rock shoals once properly removed will not reappear. With this exception no permanent improvement of the Altamaha River can ever be effected at any reasonable cost. The soil composing the bed and banks

of the river is so easily eroded that new obstructions, caused by logs, snags, and overhanging trees, form during every high-water season, and as the regimen of the river changes new shoals of rock, gravel, or sand are developed and the position and extent of sand-bars now in existence, but not at present needing improvement, will be modified. To what extent this change will take place can not be foreseen, and no accurate estimate for the improvement and maintenance of the river can now be made. The estimate submitted herewith is for the removal of the existing obstructions to navigation. When new obstructions form, estimates for their removal can then be made.

The work once completed, from $3,000 to $5,000 per year will be required to keep the river in good condition.

BRIDGES.

There is but one bridge crossing the Altamaha River. This is the Savannah, Florida and Western Railway Bridge crossing at Doctortown, 77.5 miles from the forks or 53.5 miles above Darien. It is a through trussed bridge of five spans whose lengths are, counting from the west bank to the east, respectively, 133, 122, 124.2, 122.7, and 103.8 feet. The channel is under the second span. Elevation of base of rail above low water is 41.5 feet. The clear height to the lower chord is about 37 feet. But the stage that exists during the greater part of the year, known on the river as "a good boating stage" is about 4 to 5 feet above low water. This reduces the available height ordinarily to about 32 feet, and during freshets it may not exceed 25 feet. River steamers are always compelled to lower their stacks to pass under the bridge, and during freshets some of them would be stopped entirely. The snag-boats in this district can not pass except at low water without lowering smoke-stacks and shear-frames and dismantling the pilot house. The bridge should be provided with a draw.

COMMERCE AND NAVIGATION.

The commerce which seeks the Altamaha is derived not only from the region bordering it, but also from the area bordering its tributaries, the Ocmulgee and Oconee.

For a full and detailed statement of the commerce on those rivers I respectfully refer to my reports upon the surveys of the Ocmulgee and Oconee rivers, dated February 5, 1890.

The counties bordering the Altamaha are Tatnall, Liberty, and McIntosh on the north, and Appling, Wayne, and Glynn on the south. There are but two railroads in this region to compete with the river in the carrying trade, the East Tennessee, Virginia and Georgia Railroad running approximately parallel to the river on its southern side and at an average distance of from about 15 miles from it, and the Savannah, Florida and Western Railroad crossing the river at Doctortown at about right angles to its general direction. Leaving out the parts of the above counties beyond and in the vicinity of the railroads there will remain about one-third of the counties of Appling, Wayne, Glynn, Liberty, and all of Tatnall and McIntosh, or about one-half of the whole area dependent on the river for the transportation of its produce and supplies.

The acreage of wild and improved lands, their value, and the value of all property, in the six Altamaha counties, taken from the report of

the comptroller-general of the State of Georgia for 1888, is given in the following table:

Counties.	Improved land.		Wild land.		Value city and town property.	Invested in shipping tonnage.	Aggregate value whole property.	
	Acres.	Value.	Acres.	Value.			1887.	1888.
Appling	357,074	$314,707	$333,314	$119,501	$62,240	.....	$1,042,862	$1,152,725
Glynn	45,633	419,521	140,990	265,994	196,507	$47,285	3,188,010	3,940,571
Liberty	452,349	577,494	51,546	18,868	40,865	.....	1,219,038	1,316,080
McIntosh	116,570	317,848	61,804	27,024	180,087	18,700	787,357	789,613
Tatnall	489,214	700,476	36,640	38,589	8,725	1,500	1,475,502	1,538,021
Wayne	249,886	233,635	322,385	151,011	94,333	.....	1,053,244	1,089,575
Total	1,710,726	2,563,681	949,679	520,987	2,582,757	67,485	7,766,022	9,826,585

The high value of property found for Glynn County is due to the fact that the city of Brunswick is located therein. Brunswick, however, is one of the principal markets for the produce of the Altamaha region, being the terminus of one of the lines of steamers plying the river, and may therefore be included in that territory.

No reliable statistics of the acreage and yield of farming lands can be obtained later than those of the U. S. Census of 1880.

The Macon Board of Trade estimated last year that the increase in those particulars for the counties bordering the Ocmulgee and Altamaha rivers since 1880, had been 40 per cent. Adopting this estimate for 1889 will probably give results not exceeding the true values, and the following table has been prepared on this basis:

Counties.	Population.	Corn.		Oats.		Cotton.		Potatoes.		Rice.		Wool.
		Acres.	*Bush.*	*Acres.*	*Bush.*	*Acres.*	*Bales.*	*Acres.*	*Bush.*	*Acres.*	*Pounds.*	*Pounds.*
Appling	7,386	9,542	79,202	5,736	44,231	1,496	530	530	50,459	332	143,580	48,923
Tatnall	9,783	15,387	134,664	6,723	51,735	3,665	1,349	1,010	95,406	526	256,814	51,103
Liberty	14,908	11,991	103,657	5,036	38,049	2,917	950	1,347	103,653	5,895	3,786,062	22,266
Wayne	8,372	5,940	54,756	3,063	21,708	463	166	612	72,814	339	132,563	15,714
McIntosh	8,737	3,955	48,248	485	5,876	474	145	719	56,084	5,649	5,302,237	2,895
Glynn	9,096	2,191	24,564	337	3,381	81	14	406	40,415	3,848	2,433,679	2,261
Total	58,282	49,006	445,091	21,380	164,980	9,096	3,154	4,624	418,831	16,589	12,054,935	143,162

Giving the following totals and values:

Articles.	Quantity.	Tons.	Value.	Acres.
Corn ..... bushels..	445,091	14,243	$267,034	49,006
Oats ..... do....	164,980	3,299	74,240	21,380
Cotton ..... bales..	3,154	788	157,700	9,096
Potatoes ..... bushels..	418,831	10,470	209,415	4,624
Rice ..... pounds..	12,054,935	6,027	602,746	16,589
Wool ..... do ..	143,162	72	71,581	.....
Total	.....	34,899	1,382,716	100,695

As above stated, from one-third to one-half of these products seeks the river as a means of reaching a market. But the carriage of farm produce constitutes but a small part of the commerce of the river. An immense business in lumber and naval stores has been developed in the region bordering the Altamaha and its tributaries which is entirely

dependent on these rivers. The quantities shipped increase yearly and those interested in the business estimate that the increase will continue for fifteen years to come As the timber is cleared away and the activity of the lumber and naval stores business checked, a rich farming country will be opened up and the cotton and grain raised will still seek a market by way of the river, which will offer in all cases the cheapest, and in many cases the only, means of transportation.

Besides the above-mentioned articles, the river steamers carry guano, camp supplies, mill machinery and supplies, and considerable railroad iron.

During the past year none of the commerce of the Oconee, except that in lumber, has passed through the Altamaha. From the Ocmulgee, however, about one-half of the steam-boat commerce and practically all of the lumber has gone through to the coast. This steamboat commerce amounted in value to $2,750,000, and one-half of this gives $1,375,000 for the portion passing through the Altamaha. The commerce of other boats on the Altamaha amounted to about $279,000, and the value of the logs and timber rafted was $1,260,000. The total of these three items is $2,914,000, the value of the commerce on the Altamaha for 1889.

Efforts made to obtain information as to the amount of business done by the boats on the river met with little success, the agent of the Abbeville boats alone answering. These boats, four in number, connected at Abbeville with the Savannah, Americus, and Montgomery Railway, and ran to the coast at Brunswick. This line was discontinued in October, but two of the boats were chartered by private parties and continued running independently of the railroad.

Their carrying trade up to October was as follows:

Articles.	Quantity.	Value.	Weight.
			Tons.
By boats of Savannah, Americus and Montgomery Railway:			
Rosin ..... barrels..	60,000	$150,000	7,500
Turpentine ..... do....	10,000	150,000	2,300
Cotton ..... bales..	15,000	750,000	3,750
Hay ..... do....	5,000	10,000	25
Oats ..... sacks..	10,000	9,000	400
Corn ..... do....	15,000	18,000	900
Flour ..... barrels..	5,000	25,000	490
Railroad iron ..... tons..	1,700	68,000	1,700
Salt ..... sacks..	10,000	8,000	500
Guano ..... do....	20,000	50,000	2,000
General merchandise ..... tons..	1,000	25,000	1,000
Miscellaneous ..... do....	200	5,000	200
Total	.....	1,268,000	20,765
Other sources:			
Rice ..... bushels..	125,000	125,000	3,625
Tar ..... barrels..	200	800	25
Lumber ..... feet, B. M..	90,000,000	1,260,000	21,780,000
Total	.....	1,385,800	21,783,650
Aggregate	.....	2,653,800	21,804,415

The above table does not include the business of the steamers *Abbeville* and *J. W. Sweeney* while running independently of the railroad, nor that of the steamer *Wadley* concerning which no information could be obtained.

In the preceding estimate of the total commerce of the river that of these boats was simply estimated.

In the event of the Oconee and Ocmulgee rivers being opened to navigation as far as Milledgeville and Macon respectively, and a low-water channel 3 feet in depth being maintained on all three rivers, the

commerce of the Altamaha would be greatly increased. What extent this increase would reach it is impossible to foretell, but at a moderate estimate the commerce would probably be tripled in a short time after the completion of the work. The present interests are, however, sufficient to warrant the expenditure necessary to improve the river.

Capitalized at 5 per cent., the value of the commerce would yield $145,700, an amount greater by more than $16,000 than the total estimated cost of the improvement.

Since the inauguration of works of improvement by the United States Government in 1882, the increase in the value of the commerce of this river has been $1,794,000, or for every dollar spent by the United States, $30 has been added to the commerce of the river. It is estimated by the managers of the river boats that freight rates have been reduced 30 per cent., due to the improvements already executed.

The boats engaged in the traffic on the river are stern-wheel steamers of from 200 to 230 tons burden, and drawing about 3 feet when loaded. During the past year the following boats have been running:

Name.	Manager.	Run.	Net Tonnage.	Number trips.	Total tonnage.
Swan	Savannah, Americus and Montgomery railway.	Abbeville on Ocmulgee River to Brunswick on the coast.	193.24	30	5,797.2
J. W. Sweeney	do		229.35	36	8,256.6
Abbeville	do		227.49	36	8,189.6
City of Americus	do		229.35	30	8,256.6
Wadley	Jos. Wilcox	Doctortown to Ohoopee.	200.00	96	19,200.0
Aggregate			1,079.43	228	49,700.0

In October, the Savannah, Americus and Montgomery Railway discontinued their line, but two of their boats, the *Abbeville* and *J. W. Sweeney*, continued their trips under the management of their masters.

These boats have been much embarrassed during the past year by the bar at Beard's Bluff. The river remained at a low stage for about six months and during this period the steamers were compelled to partially or wholly unload and lighter their cargoes across the bar, then reload and continue the trip. In one instance, a delay of three days was occasioned. The necessity of early attention to the improvement of this bar can not be too strongly urged since the through traffic from the upper rivers to the coast, as well as the local traffic of the Altamaha, depends thereon.

The steamer *Wadley* discharges its freight at Doctortown whence it is taken by rail to Savannah. The other steamers run through to Brunswick. The lumber is rafted to Darien, Doboy, Sapelo and St. Simons, whence it is shipped to coastwise and foreign ports. It would probably all go by way of Darien and Doboy were it not for the shoaling of Doboy Bar which prevents deep draught vessels from clearing in that port. Most of the foreign shipments are therefore made at St. Simons and Sapelo.

The cost of the improvement of the Altamaha River with a view to obtaining a navigable channel 3 feet in depth at ordinary summer low water is estimated in round numbers at $129,000.

The sum of $45,000 can be advantageously and economically expended during the present fiscal year.

I desire to express my obligations to my assistant, Lieut. Thos. H. Rees, Corps of Engineers, U. S. Army, the preparation of this report having been mainly his work.

The following maps accompany this report:

(1.) Index map of Altamaha River from forks to Darien.
(2.) General map of Altamaha River from the forks to Darien and map of detailed surveys.
(3.) Profile of the Altamaha River, forks to Darien.

Respectfully submitted.

O. M. CARTER,
First Lieutenant Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. F. C. ARMSTRONG, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., June 30, 1890.

SIR: The snag-boat *Toccoa* stopped work on the Savannah River November 13, 1889; ran to Savannah (making 7 miles per hour), and from there to the Altamaha River, beginning snag-work on November 22, 1889.

The Altamaha River had been cleared of the worst obstructions by the "old" *Toccoa*, and the work done this year leaves the river in good condition, as regards snags.

A summary of the work done is here given:

Month.	Total days worked.	No. of days removing obstructions.	Explosives used, pounds.	Snags over 6 inches.	Snags under 6 inches.	Stumps.	Overhanging trees, over 6 inches.	Overhanging trees, under 6 inches.	Logs cut up on bank.
1889.									
November	15	7	.....	26	12	1	22	9	3
December	21	17	15	77	11	4	99	151	7
1890.									
January	8	8	.....	34	10	.....	16	12	.....
Total	44	32	15	137	33	5	137	172	10

Location.	Distance from Couper's Bar.	Explosives used, pounds.	Snags over 6 inches.	Snags under 6 inches.	Stumps.	Overhanging trees over 6 inches.	Overhanging trees under 6 inches.	Logs cut up on bank.
	Miles.							
Sansavilla	22	.....	11	10	1	.....	.....	.....
Phinholloway	30½	.....	4	1	.....	6	.....	.....
Box Pt.	31	.....	4	1	.....	.....	.....	.....
Bugg Suck	33	.....	8	1	.....	52	95	5
Steam-boat Cut	35 to 36	.....	29	7	.....	.....	.....	2
Mad-dog Pt.	42	.....	5	.....	1	18	47	.....
Indian Pt. Bluff	46½	.....	10	.....	1	5	14	.....
Oglethorpe Reach	59	.....	12	.....	.....	3	.....	.....
Marrowbone Round	62	.....	4	.....	.....	9	2	3
Shoulderblade Round	70¼	.....	5	2	1	11	.....	.....
Stooping Gum Cut	71¼	15	11	1	1	17	2	.....
Scattering, from	71¼ to 127	.....	34	10	.....	16	12	.....
Total	.....	15	137	33	5	137	172	10

(Distances on the map are from the forks of the Oconee and Ocmulgee, and as all other rivers are from the mouth, I have taken Couper's Bar, as at that point boats from Darien enter the Altamaha River.)

The work for the ensuing year will consist of the removal of scattering snags over the entire 127 miles. There are a few from Couper's Bar (0) to Lower Sansavilla (21). Then through the Narrows, from Phinholloway (30½) to Hannah Island (43). This reach will require the most attention. Above here some work will be necessary at Stooping Gum (71½), Wild Cow Round (73½), Upper Sister Bluff (79½), and at intermediate points, where probably one or two snags necessary to remove will be found; but no work of any magnitude in any one locality. The boilers of the sunken steamer *Tar Heel* at Oswell's Cut (56) should be removed, as they are in the channel. I believe that a period of three months will be sufficient to complete the necessary work.

Beard's Bluff Bar (66½) has given steam-boat men so much trouble that they do not consider the snags at all. The last year has been one of unusual low water and probably 50 per cent. of the freights have been lightered over this bar, or the boats have been detained so long here that it would have been more economical to lighter.

Very respectfully, your obedient servant,

F. C. ARMSTRONG,
Assistant Engineer.

Lieut. O. M. CARTER,
Corps of Engineers, U. S. A.

Arrivals and clearances of vessels at Darien, Georgia, from January 1, 1875, *to December* 31, 1889.

ARRIVED.

Year.	Coastwise.			Foreign ports.						Total.			Greatest draught.
				American vessels.			Foreign vessels.						
	No.	Tons.	Crew.	No.	Tons.	Crew.	No.	Tons.	Crew.	No.	Tons.	Crew.	
													Ft.
1875	77	28,053	647	....	.....	.....	92	47,600	1,198	169	75,663	1,845	22
1876	65	23,105	611	....	.....	.....	124	70,368	1,897	189	93,473	2,508	21
1877	104	24,827	1,257	3	674	22	99	50,913	1,231	206	106,414	2,510	20
1878	61	29,264	641	2	1,051	20	126	60,109	1,628	189	90,424	2,289	20
1879	58	23,275	487	3	1,199	25	115	57,710	1,407	176	82,184	1,919	19½
1880	66	21,539	489	1	688	13	134	68,072	1,608	201	90,270	2,140	19½
1881	101	40,619	849	3	1,220	29	162	84,457	1,991	166	126,295	2,869	19½
1882	117	48,208	999	1	453	9	90	51,421	1,155	208	100,082	2,163	19
1883	95	38,173	815	...	.....	.....	93	49,790	1,135	188	87,963	1,950	19
1884	81	34,412	714	2	606	16	92	50,178	1,133	175	85,193	1,863	19
1885	78	27,763	691	2	652	16	80	42,587	975	160	71,002	1,673	18½
1886	108	44,389	852	....	.....	.....	42	20,772	483	150	65,161	1,335	19
1887	127	57,035	1,059	5	2,349	45	26	13,023	298	158	72,407	1,402	....
1888	185	77,645	1,558	1	402	9	22	13,423	273	208	91,470	1,840	18½
1889	145	69,763	1,341	7	4,349	62	61	19,837	453	213	93,949	1,856	18½

CLEARED.

1875	22	12,214	328	11	4,055	97	104	55,759	1,372	137	72,028	1,797	22
1876	39	9,300	270	4	1,553	32	180	87,489	2,263	223	98,342	2,565	21
1877	44	13,209	314	4	812	21	169	92,795	2,154	217	106,846	2,489	26
1878	28	7,842	181	6	3,009	62	149	83,385	1,947	183	94,236	2,190	20
1879	40	14,052	301	7	2,765	57	125	65,413	1,538	172	82,250	1,896	19½
1880	55	17,076	393	7	3,589	72	168	84,172	2,016	230	104,837	2,481	19½
1881	80	28,492	617	8	3,120	70	184	95,353	2,164	272	126,965	2,851	19½
1882	93	34,098	709	6	1,962	46	115	63,525	1,434	214	99,585	2,189	19
1883	66	25,019	510	9	3,533	72	108	56,411	1,340	183	84,963	1,931	19
1884	59	20,637	457	11	3,977	85	119	66,337	1,478	189	90,951	2,020	19
1885	46	16,649	339	8	3,354	62	98	52,742	1,198	152	72,745	1,599	18½
1886	93	38,295	719	10	3,687	80	50	24,376	564	153	66,358	1,363	19
1887	126	55,944	1,016	12	1,144	17	16	8,612	189	144	65,700	1,222	....
1888	155	64,749	1,318	2	538	15	36	23,742	453	193	89,029	1,786	19
1889	155	63,347	2,091	6	4,333	66	46	26,488	528	207	94,168	2,685	....

Timber shipments from port of Darien, Georgia, from January 1, 1875, to December 31, 1889.

Year.	Foreign.		Coastwise.		Total.	
	Superficial feet.	Value.	Superficial feet.	Value.	Superficial feet.	Value.
1875	41,447,024	$557,524	10,992,600	$181,377.00	52,439,624	$738,901.00
1876	60,762,000	735,099	8,370,000	138,105.00	69,132,000	873,204.00
1877	64,378,000	776,856	11,888,100	196,153.65	76,266,100	973,009.65
1878	59,697,124	716,365	7,057,800	116,453.70	66,754,924	832,818.70
1879	47,217,818	566,613	12,646,800	208,672.20	59,804,618	775,285.20
1880	74,612,520	895,350	15,368,500	253,578.60	89,981,020	1,148,928.60
1881	65,420,876	785,050	25,642,800	423,106.20	91,063,676	1,208,156.20
1882	36,639,379	439,672	30,688,200	506,355.30	67,327,579	946,027.30
1883	42,385,600	508,620	22,517,100	371,532.15	64,902,100	880,152.15
1884	50,656,000	607,872	18,573,300	306,459.45	69,229,300	914,331.45
1885	40,101,000	501,262	14,984,100	247,937.65	55,085,100	749,199.65
1886	19,960,000	219,500	24,465,000	661,440.00	54,425,000	870,940.00
1887	12,023,611	138,476	50,349,600	912,220.00	62,373,211	1,056,960.00
1888	17,975,371	215,705	65,998,200	1,121,960.00	83,975,571	1,337,665.00
1889	20,772,265	237,652	50,667,600	760,144.00	71,449,865	997,816.00

Commerce.

Year.	Value of exports.	Value of imports.	Total collections.
1880	$1,621,904	$5,600	$11,806.72
1881	1,137,490	3,356	18,980.02
1882	1,073,008	1,025	11,254.19
1883	969,834	2,334	11,067.37
1884	1,038,185	11	9,688.20
1885	860,500	.....	2,359.01
1886	1,037,330	.....	.....
1887	1,221,000	.....	.....
1888	2,100,000	2,600	964.13
1889	997,816	None.	None.

O 6.

IMPROVEMENT OF OCONEE RIVER, GEORGIA.

The Oconee River rises in the northeastern part of Georgia, flows in a southeasterly direction, and unites with the Ocmulgee to form the Altamaha. A detailed description of this river is given in my report of the preliminary examination and survey, printed as House Ex. Doc. No. 211, Fifty-first Congress, First Session. For a special history of past work, see page 1253, Annual Report Chief of Engineers for 1889.

ORIGINAL CONDITION.

For the greater part of the year the river is navigable for steamboats drawing from 3 to 4 feet, but during the low-water season there are various shoals with low-water depths of not more than 2 feet. The chief obstruction to navigation consists of sand-bars, overhanging trees, snags, and sunken logs.

PLANS OF IMPROVEMENT.

The plan of improvement, as outlined in my report of February 5, 1890, provides for the establishment of a navigable steam-boat channel

3 feet deep at ordinary summer low water from Milledgeville to the river's mouth.

This is to be accomplished by (1) Removing rafts, rock-shoals, and sand-bars. (2) Enlarging portions of the river, revetting caving banks, and closing incipient cut-offs. (3) Removing snags and logs from the channel and overhanging trees from the banks of the stream.

The cost of the improvement is estimated at $171,000, provided funds are regularly and adequately supplied.

SUMMARY OF OPERATIONS PRIOR TO JUNE 30, 1889.

Between 1815 and 1842 about $45,000 were expended by the State of Georgia in the improvement of this river, and between 1874 and 1875 about $8,575 were expended by the Oconee Steam-boat Company between Dublin and the Central Bridge, a distance of 28 miles. Operations under the project adopted in 1878 were begun in 1878, and have been carried on at irregular intervals, as the available funds allowed, ever since. A specific appropriation of $1,500 for improving the section of river between Skull Shoals and the Georgia Railroad Bridge was expended so as to give a least depth in that reach of 20 inches at extreme low water.

In all there have been removed from the river 3,154 snags and logs, 2,429 overhanging trees, and 487 cubic yards of rock. Some small brush jetties have been built, 28 trees have been deadened, and 48 logs cut up on bank.

Up to July 1, 1889, the total expenditure for the work, including outstanding liabilities, amounted to $34,642.81.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

Active operations during the fiscal year consisted in the removal of logs, snags, overhanging trees, etc. Overhanging trees have been removed between the mouth of the river and Little Buzzard Bar. The *Steam Hoister* was employed upon this work from December 19, 1889, to January 12, 1890, and two bank parties from November 4 and 29, 1889, to March 25, 1890.

The snag-boat *Ocmulgee* was employed from December 30, 1889, to April 8, 1890, operating between Browning's Old Field and Little Buzzard Bar. Operations were suspended in April on account of the exhaustion of funds.

During the fiscal year just closed there were removed from the river channel 948 snags and logs and 52 stumps; 15,220 overhanging trees were felled, 511 trees were girdled and 219 logs were cut up on the river bank.

CONDITION OF WORK JUNE 30, 1890.

The river is in a fair condition where work has been done, but still needs much attention. Between Little Oakey Bluff and Shady Field, work is especially needed. Above Dublin the Central Railroad Bridge and a raft obstruct navigation. The work already done has been of great benefit to navigation, boats now running at stages of water from 2 to 3 feet lower than before the improvements were begun.

A detailed description of the present condition of the river is given in my report upon the survey, and those localities urgently requiring attention are given in the appended report of my assistant engineer, Mr. F. C. Armstrong, in local charge of work of removing obstructions.

COMMERCE AND NAVIGATION.

The Oconee River is navigable from the mouth to the Central Railroad Bridge, a distance of 108 miles. This bridge being without a draw prevents boats from running above that point, and some portions of the river below it are so obstructed by snags and shoals that no regular runs are made through them. The boats engaged in the river traffic during the year 1889 were the *Tommie*, running from Little Oakey Bluff, 34 miles from the Forks to Ocmulgee Station where the East Tennessee, Virginia and Georgia Railway crosses the Ocmulgee River 12 miles from the Forks, and the steamer *Laurens* running from Dublin (79 miles) to Red Bluff (41 miles) and making occasional trips up the river from Dublin. The steamers, *Lumber City* and *Ida*, also occasionally make the same trip as the *Tommie*, but ordinarily run on the Ocmulgee River only.

List of steam-boats plying Oconee River, Georgia, since 1880.

[R.—Local to Ravne Station, on Central Railroad. L.—Local to Lumber City, on East Tennessee, Virginia and Georgia Railroad. C.—To coast.]

Name.	Tons	1880-'81.	1881-'82.	1882-'83.	1883-'84.	1884-'85.	1885-'86.	1886-'87.	1887-'88.	1888-'89.	1889-'90.
Colville	75	R.	R.								
Wadley	190			C.	C.	C.					
Ida	296	L.	L.	L.	L.	L.					
Halcyon	325			C.							
Cumberland	275	C.	C.	C.	C.						
Laurens	180				R.	R.	R.	R.	R.	R.	R.
Mary Cooper	150					L.					
North State	180					L.					
Tommie							L.	L.	L.	L.	L.

A new boat is being built at Dublin to engage in the river trade, and will have double the capacity of any one of the present steamers.

The commerce of these boats consists of naval stores, cotton, rice, corn, oats, wool, guano, camp-supplies and general merchandise.

Statements of the shipments for the year 1889 were received from but one of the river steamers in answer to requests from this office.

The following table is prepared from this statement, and shipments by other boats are estimated:

Shipments per steamer Tommie.

	Quantity.	Value.	Weight.
			Tons.
Turpentine.....barrels..	3,300	$49,500	760
Rosin.....do....	10,000	25,000	1,250
Cotton.....bales..	600	27,000	150
Rice.....pounds..	7,000	17,500	700
General merchandise.....tons..	1,700	65,000	1,700
Total.....		184,175	4,563
Per steamer *Laurens* (estimated).....		350,000	9,000
Other steamers (estimated).....		150,000	4,000
Timber rafted.....feet..	25,000,000	300,000	60,450
Total.....		984,175	78,013

An estimate of the commerce that would probably be developed, provided the river were placed in a thoroughly navigable condition from Milledgeville to the mouth, is given in Mr. A. S. Cooper's report on the survey of the Oconee River submitted with my report of February 5, 1890, to which I would respectfully refer.

A line of boats could be established from Milledgeville to the coast. Regular and more frequent trips could be made and heavier loads carried during low-water stages. A large section of farming and timber lands would be opened up and increased dependence would be placed on the river as a means of transportation for all classes of freight. In the counties bordering the Oconee River the population is about 90,000, the area of cultivated lands about 507,000 acres, and the value of all property from $10,000,000 to $11,000,000. The area tributary to the river is about 1,900 square miles.

In view of the information collected, it is estimated that the commerce on the river after improvement would amount to three times its present value.

MISCELLANEOUS.

Water-gauges were read at Dublin and Milledgeville until June 1, 1890, when the exhaustion of the appropriation necessitated their suspension.

The work is located in the collection district of Brunswick, Ga. Darien is the nearest port of entry. Amount of duties collected in 1889, $8,933.66. Sapelo Light is the nearest light-house, and Forts Oglethorpe and Pulaski are the nearest forts.

Since the existing project for improving the Oconee River was adopted the following appropriations have been made for the work:

June 18, 1878	$10,000	July 5, 1884	$3,000
March 3, 1879	1,500	August 5, 1886	9,000
June 14, 1880	1,500	August 11, 1888	12,500
March 3, 1881	2,500		
August 2, 1882	5,000	Total	45,000

The total expenditures to June 30, 1890, including all outstanding liabilities, were $44,822,18.

As outlined in my project of February 5, 1890, it is proposed to expend any funds which may become available during the year in the removal of obstructions and in the improvement of the shoals in the river between Milledgeville and the mouth, should the railroad bridge near Oconee Station be so altered as to allow work to be done above that point.

The sum of $50,000 can be economically and advantageously expended during the coming year. No permanent improvement can be effected, as new obstructions, caused by logs and snags, form during every high-water season. They should, however, become fewer in number each year. From $1,000 to $5,000 will be required for the annual maintenance of the completed work. The work of removing obstructions has been in the local charge of Mr. F. C. Armstrong, assistant engineer, whose report is appended hereto.

Money statement.

July 1, 1889, amount available		$10,357.19
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$10,156.01	
July 1, 1890, outstanding liabilities	23.36	
		10,179.37
July 1, 1890, balance available		177.82
Amount appropriated by act of September 19, 1890		25,000.00
Amount available for fiscal year ending June 30, 1891		25,177.82
Amount (estimated) required for completion of existing project		146,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		50,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. F. C. ARMSTRONG, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., June 30, 1890.

SIR: The operations on the Oconee River have been confined to snag work and the removal of overhanging trees.

In 1888-'89 the river was cleared of the worst obstructions from the Forks (0) to Devil's Cut (18½). From this point to Little Oakey Bluff (34¼), a distance of 15¾ miles, and from Shady Bluff (63) to Little Buzzard Bar (74), a distance of 11 miles, the worst obstructions have been removed by the snag-boat *Ocmulgee*, from December 30, 1889, to April 8, 1890.

The overhanging trees have been removed from Little Buzzard Bar (74) to the Forks (0), a distance of 74 miles, by the steam-hoister, from December 19, 1889, to January 12, 1890, and by two bank parties, from November 4 and 29, 1889, to March 25, 1890. All overhanging trees were pulled back by hand.

A summary of work done is here given. Snags reported as "over 6 inches" would average 18 inches, and many of them weighed 20 tons and more. All were removed whole; no cutting was done.

Detailed statement of work done to date.

Period.	Snags.		Stumps.		Overhanging trees.		Trees girdled.	Logs cut up on bank.	Cubic yards of rock removed.
	Over 6 inches.	Under 6 inches.	Over 6 inches.	Under 6 inches.	Over 6 inches.	Under 6 inches.			
1878 to 1879: (Report of Chief of Engineers, 1889)	2,435	463	112	194	1,705	724	28	48	487
1889-'90	759	189	52	.....	6,471	8,749	511	219	.....
Total to June 30, 1890.	3,194	652	164	194	8,176	9,473	539	267	487

Twenty-five cubic yards log and brush jetties and 6 tons of rock removed.

SNAG-BOAT OCMULGEE.

Date.	Total days worked.	No. of days removing obstructions.	Explosives used.	Snags.		Stumps.	Overhanging trees.		Trees girdled.	Logs cut up on bank.
				Over 6 inches.	Under 6 inches.		Over 6 inches.	Under 6 inches.		
1889.			*Pounds.*							
December	2	.....	.....	.....	.....	.....	.....	.....	.....	.....
1890.										
January	27	26	14½	247	68	13	23	51	.....	.....
February	24	21	8	195	44	14	5	6	.....	.....
March	26	25	.....	201	48	24	3	3	.....	.....
April	10	7	.....	67	11	1	7	2	.....	.....
Total	89	79	22½	710	171	52	38	62	.....	.....

STEAM-HOISTER.

1889.										
December	.....	4	.....	8	.....	.....	40	75	.....	4
1890.										
January	.....	18	.....	41	18	.....	370	538	18	8
Total	.....	22	.....	49	18	.....	410	613	18	12

Detailed statement of work done to date—Continued.

BANK PARTY NO. 1.

Date.	Total days worked.	No. of days removing obstructions.	Explosives used.	Snags.		Stumps.	Overhanging trees.		Trees girdled.	Logs cut up on bank.
				Over 6 inches.	Under 6 inches.		Over 6 inches.	Under 6 inches.		
1889.										
November		23					401	1,077	45	98
December		22					409	749	33	7
1890.										
January		13					413	726	21	30
February		24					1,133	845	230	20
March		22					781	600	99	15
Total		104					3,137	3,997	428	170

BANK PARTY NO. 2.

1889.										
November		2					100	65		
December		20					1,065	1,591	14	4
1890.										
January		12					387	760	13	2
February		24					716	804	21	9
March		19					618	857	17	22
Total		77					2,886	4,077	65	37
Grand total	89	282	22½	759	189	52	6,471	8,749	511	219

Summary of work by localities: Snag-boat Ocmulgee.

Locality.	Distance above forks.	Snags.		Stumps.	Overhanging trees.		Explosives used.
		Over 6 inches.	Under 6 inches.		Over 6 inches.	Under 6 inches.	
	Miles.						*Lbs.*
Browning's Old Field	13¼	2					
Goodwin's Cut	19	13	3				
	19½	9					
	19¾	10	3	2			
	21½	1					
McLeod's Cut	22¼	7	5	3			
	22¾	2		3			
Salt House	23¾	11	2	1	1		
	24	5		1			
Below Mitchell's Lake	24¼	21	6	1	9	4	4½
Below Adams's Landing	24¼	21	7	1			
Above Adams's Landing	24½	12	3		4		
The "Whirl"	26½	13	5				
Bird's Cut	27	122	38	11	6	36	10
	27¾	11	1		1		
Below Joyce's Ferry	28¾	14	2		3	11	
	29	22	6				
Joyce's Ferry	29½	13	3				
McWilliams's Landing	30¼	15	2				
Joyce's Bluff	32¼	7	1		2		
	32½	14				4	
Bingham's Landing	32¾	11	5				
	33	5	2				
	33½	4	1				
	33¾	10	1				
Little Oakey Bluff	34	7			2	2	
	34½	2					

Summary of work by localities: Snag-boat Ocmulgee—Continued.

Locality.	Distance above forks.	Snags.		Stumps.	Overhanging trees.		Explosives used.
		Over 6 inches.	Under 6 inches.		Over 6 inches.	Under 6 inches.	
	Miles.						*Lds.*
Rifle Cut	43¼	11	3	1	.....	.....	.....
Gage's Bight	50¼	2	.....	.....	.....	.....	.....
	62¾	1	.....	.....	.....	.....	.....
Flat Creek	62¾	12	.....	.....	7	2	.....
Shady Field Cut	63¾	8	5	.....	.....	.....	.....
Green's Folly	65	18	1	1	.....	.....	.....
	66¼	1	.....	.....	.....	.....	.....
	67¼	21	8	2	.....	.....	.....
	67½	23	7	1	.....	.....	8
Below Poor Robin Landing	67¾	14	1	.....	.....	.....	.....
Poor Robin Landing	68	2	.....	1	.....	.....	.....
Ring Jaw Bight	68½	30	3	1	.....	.....	.....
	68¾	1	.....	.....	.....	.....	.....
	70	16	1	2	1	3	.....
	70¼	24	8	1	.....	.....	.....
	70½	1	.....	.....	.....	.....	.....
	70¾	8	1	.....	.....	.....	.....
Fish Trap Cut	72¼	39	8	7	2	.....	.....
Do	72½	7	.....	6	.....	.....	.....
	73	24	12	5	.....	.....	.....
Drowning Cow Bight	73¼	14	5	.....	.....	.....	.....
Big Buzzard Bar	73½	20	4	.....	.....	.....	.....
	73¾	15	7	.....	.....	.....	.....
Little Buzzard Bar	74	11	1	1	.....	.....	.....
Total	.....	710	171	52	38	62	22½

The year 1889–'90 has been very favorable to snag-work, the stage of water averaging 4 feet above low.

The river is in a fair condition where worked, but a snag-boat can be profitably employed an entire year on this river. From Little Oakey Bluff (34) to Shady Field (63) the work is especially needed and should be worked first.

At the following points the sloughs, constituting incipient cut-offs, should be closed:

Locality.	Miles above forks.	Locality.	Miles above forks.
Devil's Elbow	3¾	Mitchell's Lake	24¼
Steam-boat Bight	7½	Joyce's Bluff	32¼
Frying Pan River	18–21	Jones's Old River	37–40
Devil's Trash Pile	18½	Bonny Clabber	52½
	23	Fish Trap Cut	72½

Frying Pan River (18–21) is not capable of carrying the entire volume without further cutting, which would cause more trouble from snags, and probably at a time when no assistance could be given. The west channel, however, should be obstructed so as to throw a greater volume into Frying Pan River.

Jones's Old River (37–40) should be closed at 38 miles, and Centre Cut (38) opened.

Fish Trap Cut (72½) should either be opened or closed, and I believe it easier to open. Then the worst part of the shoal will be passed. If it is closed, then a party should be put in the shoals to cut a gap.

The present bridge of the Savannah, Americus and Montgomery Railway at Mt. Vernon is an obstruction to navigation, and the permanent structure should be built at once.

The following is a list of boats plying on this river:

[L—Local feeder to East Tennessee, Virginia and Georgia Railway at Lumber City. D—Local feeder to Wrightsville and Tennille Railroad and Georgia Central at Dublin.]

Name.	Tons.	Route.	Name.	Tons.	Route.
Ida	296	L	Laurens	180	D
Lumber City	227	L	Americus	240	D
Tommie	180	L			

The following freights were carried by these boats from July 1, 1889, to June 30, 1890:

Articles.	Quantity.	Weight.
		Tons.
Rosin ..... barrels..	56,000	14,000
Spirits of turpentine ..... do....	12,500	3,125
Cotton ..... bales..	3,900	975
Guano ..... tons..	2,000	2,000
Merchandise ..... do....	3,000	3,000
Total	.....	23,100

Thirty million feet of lumber were also rafted.

The snag-boat *Ocmulgee* was in charge of Overseers J. D. Robeson and J. G. Walker; the steam-hoister was in charge of Foreman Martin McGuffog, and the bank parties were in charge of Foremen Joseph Davis and T. J. Daniels.

All distances given are from the survey of 1889.

Very respectfully, your obedient servant,

F. C. ARMSTRONG,
Assistant Engineer.

Lieut. O. M. CARTER,
Corps of Engineers, U. S. A.

O 7.

IMPROVEMENT OF OCMULGEE RIVER, GEORGIA.

The Ocmulgee River is formed by the juncton of the South and Yellow rivers about 20 miles below Covington, and flows thence in a southeasterly direction about 250 miles, where it unites with the Oconee to form the Altamaha. A detailed description of this river is found in my report of the preliminary examination and survey, printed as House Ex. Doc. No. 215, Fifty-first Congress, first session. For a special history of past work, see page 1258, Annual Report Chief of Engineers for 1889.

ORIGINAL CONDITION.

For the greater part of the year the river is navigable for steam-boats drawing from 3 to 4 feet, but during the low-water season there are various shoals with depths of not more than 2 feet. The chief obstructions to navigation consist of rock shoals, sand-bars, overhanging trees, snags, and sunken logs.

PLAN OF IMPROVEMENT.

The plan of improvement, as outlined in my report of February 5, 1890, provides for the establishment of a navigable steam-boat channel 3 feet deep at ordinary summer low water from Macon to the river's mouth.

This is to be obtained by: (1) Removing rock shoals and sand-bars; (2) closing incipient cut-offs and revetting caving banks; (3) removing snags and logs from the channel and overhanging trees from the banks of the stream.

The cost of the improvement is estimated at $210,000, provided funds are regularly and adequately supplied.

SUMMARY OF OPERATIONS PRIOR TO JULY 1, 1889.

A detailed statement of the present condition of the river is given in my report upon the survey, and those localities urgently requiring

attention are given in the appended report of my assistant engineer, Mr. F. C. Armstrong.

SUMMARY OF OPERATIONS PRIOR TO JULY 1, 1889.

Between 1817 and 1837 the State of Georgia expended about $60,000 in the improvement of the river, $10,000 of which were used above Macon. In August, 1877, operations were begun under the project approved by Congress in 1876, and the work has been carried on at intervals, as funds were available, up to June 30, 1889, when operations were suspended on account of lack of funds. In all, there have been removed from the river 5,749 snags, 5,461 overhanging trees, 359 cubic yards of rock, and 1,869 cubic yards of earth; 87 logs were cut up on the banks, 186 trees were deadened, two jetties were built at Tillman's Bar, two snag dams at Ashley's Landing, and one at Indian Timber Landing. Up to July 1, 1889, the total expenditure for the work, including outstanding liabilities, amounted to $67,987.70.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

Operations during the year consisted in removing logs, snags, overhanging trees, etc., between the mouth of the river and Hawkinsville, a distance of 133 miles.

The *Steam Hoister* removed overhanging trees between Rocky Creek and Hawkinsville, a distance of 88 miles.

The snag-boat *Ocmulgee* worked from July 1, 1889, to December 21, 1889, between Rocky Creek and Abbeville; the snag-boat *Toccoa* from January 10 to March 18, 1890, between the mouth of the river and Hawkinsville, the principal work being done between the latter point and Abbeville.

Operations were suspended in March on account of the exhaustion of funds.

During the fiscal year just closed there were removed from the river channel 1,829 snags and logs and 127 stumps; 7,683 overhanging trees were felled, 615 trees were girdled, and 25 logs were cut up on the river bank.

CONDITION OF WORK JUNE 30, 1890.

The river is in fair condition, so far as snags and overhanging trees are concerned, from its mouth to Hawkinsville, still much yet remains to be done over that section of the river.

Above Hawkinsville, highway and railroad bridges have prevented work. These are to be removed. The work already done has been of great benefit to navigation. Boats now run at a stage of water from 3 to 4 feet lower than before the improvements were begun.

A detailed statement of the present condition of the river is given in my report upon the survey, and those localities urgently requiring attention are given in the appended report of my assistant engineer, Mr. F. C. Armstrong, in local charge of removing obstructions.

COMMERCE AND NAVIGATION.

In the early navigation of this river, about the beginning of the present century, pole-boats were used. Afterwards small steamers were added to tow up-stream the flats which brought cargoes down-stream with the current, and finally, about 1830, larger freight steamers took

the place of tow-boats and flats. Since then a considerable and growing traffic has been carried on. Macon was originally the head of navigation, and through freights were carried from there to the sea-coast. The building of the Central Railroad to Macon in 1845 diminished the traffic on the Upper Ocmulgee, and finally the construction of a highway bridge at Hawkinsville made that point the actual head of navigation, and cut off the fertile and finely timbered region between Hawkinsville and Macon from its natural means of communication with the markets. Below Hawkinsville the river traffic continued, but boats were able to run only six or eight months of the year, being stopped at low water by snags, bars, and ledges. Now, however, owing to the works of improvement begun in 1877, boats are rarely stopped at low water, running at a stage 3 feet lower than the former limiting stage, and freight rates have been reduced at least 40 per cent. But the low-water navigation is still dangerous on account of snags and shoals, and reduced loads must be carried at this stage.

The boats engaged in the river commerce since 1879 are given in the following table:

The following gives the number of boats on this river from 1879 to date:

[C.—Runs to coast. A.—Runs to coast, connecting with Americus, Preston and Lumpkin Railroad at Abbeville. L.—Local feeder to East Tennessee, Virginia and Georgia Railroad at Lumber City. H.—Local feeder to East Tennessee, Virginia and Georgia Railroad at Hawkinsville.]

Name.	Tons.	1879–'80.	1880–'81.	1881–'82.	1882–'83.	1883–'84.	1884–'85.	1885–'86.	1886–'87.	1887–'88.	1888–'89.	1889–'90.
Mary Fisher	240	C.	C.	C.	.....	.....	.....	.....	.....	.....	.....	.....
Halcyon	325	C.	C.	C.	C.	C.	.....	.....	.....	.....	.....	.....
Cumberland	275	C.	C.	C.	C.	C.	C.	.....	.....	.....	.....	.....
Clyde	200	.....	L.	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ida	296	.....	L.	L.	L.	L.	L.	L.	L.	L.	L.	L.
Wadley	190	.....	.....	.....	.....	C.	C.	.....	.....	.....	.....	.....
North State	180	.....	.....	.....	.....	C.	C.	.....	.....	.....	.....	.....
Colville	75	.....	.....	.....	.....	H.	H.	H.	.....	.....	.....	.....
Mary Jeter	110	.....	.....	.....	.....	H.	H.	H.	H.	.....	.....	.....
Mary Cooper	150	.....	.....	.....	.....	.....	L.	L.	.....	.....	.....	.....
Tommie	180	.....	.....	.....	.....	.....	.....	.....	.....	L.	L.	L.
Lumber City	227	.....	.....	.....	.....	.....	.....	.....	.....	.....	L.	L.
Swan	193	.....	.....	.....	.....	.....	.....	.....	.....	C.	A.	A.
Americus	240*	.....	.....	.....	.....	.....	.....	.....	.....	.....	A.	A.
Abbeville		.....	.....	.....	.....	.....	.....	.....	.....	.....	A.	A.
J. W. Sweeney		.....	.....	.....	.....	.....	.....	.....	.....	.....	A.	A.
J. C. Stewart	129*	.....	.....	.....	.....	.....	.....	.....	.....	H.	H.	H.
Abbe	110*	.....	.....	.....	.....	.....	.....	.....	.....	H.	H.	H.
New South	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	H.

*About.

Steam-boats on Ocmulgee River during year 1889–'90.

Line.	No.	Name.	Length.	Beam.	Depth.	Tonnage.		No. of trips (about).	Total tonnage (net).
						Gross.	Net.		
			Feet.	*Feet.*	*Feet.*				
Hawkinsville boats.	1	Abbe	106	26	4.4	240.26	120.13	30	3,603.90
	2	J. C. Stewart	100	24	3.9	235.84	129.05	40	5,162.00
	3	New South	.....	.....	.....	.....	.....	.....	.....
Abbeville boats.	4	Swan	103	29	4.7	336.30	193.24	30	5,797.20
	5	J. W. Sweeney	118.9	34.4	4.4	414.73	229.35	36	8,256.60
Savannah, Americus and Montgomery Railway line.	6	Abbeville	118.9	34.4	4.4	414.73	227.49	36	8,189.60
	7	Americus	118.9	34.4	4.4	414.73	229.35	30	6,880.50
Lumber City boats.	8	Tommie	108	22	3.9	282.89	175.29	100	17,529.00
	9	Ida	115	24	5.5	296.19	181.04	50	9,052.00
	10	Lumber City	115	23	5.4	330.71	227.95	50	11,397.50
Aggregate	....	.....	.....	.....	.....	.....	1712.89	402	75,868.30

The value of the commerce of these boats in 1889 is as follows:

Hawkinsville boats (estimated)	$500,000
Lumber City boats	610,000
Savannah, Americus and Montgomery Railway boats, Abbeville to coast	1,450,000
	2,560,000
Adding to this the value of round and hewn timber rafted, 30,000,000 feet B. M. at $12 per M	360,000
Total commerce	2,920,000

This can not, however, be taken as an average yearly value, since the Savannah, Americus and Montgomery Railway has extended its line from Abbeville to Savannah and the freights carried by their boats from Abbeville to Brunswick have, since last October, gone by rail to Savannah. Two of these boats have since then been running independent of the railroad and doing a business which would amount for the whole year to about $500,000, making the legitimate river commerce for the year $1,970,000. This is an increase of at least $1,000,000, since works of improvement were inaugurated in 1887, and is equivalent to about $13 increase for every dollar expended by the United States.

Shipments per Savannah, Americus and Montgomery Railway boats in 1889, *up to October.*

	Quantity.	Value.	Weight.
			Tons.
Rosin, barrels	60,000	$150,000	7,500
Turpentine, do	10,000	150,000	2,300
Cotton, bales	15,000	750,000	3,750
Hay, do	5,000	10,000	625
Oats, sacks	10,000	9,000	400
Corn, do	15,000	18,000	900
Flour, barrels	5,000	250,000	490
Railroad iron, tons	1,700	680,000	1,700
Salt, sacks	10,000	8,000	500
Guano, do	20,000	50,000	2,000
General merchandise, tons	1,000	25,000	1,000
Miscellaneous, do	200	5,000	200
Total		1,268,000	21,365

Shipments per Lumber City boats.

	Quantity.	Value.	Weight.
			Tons.
Naval stores, bbls	40,000	$260,000	6,050
Cotton, bales	1,800	90,000	450
Rice, lbs	20,000	500	10
Guano, tons	2,000	60,000	2,000
General merchandise, do	5,200	200,000	5,200
Total		610,500	13,710
Per Savannah, Americus and Montgomery Railway boats as above		1,268,000	21,365
Estimated shipments of other boats		681,500	12,400
Aggregate		$2,560,000	47,475

A full and carefully prepared statement of the conditions and circumstances that will affect this commerce in the event of the river being placed in a thoroughly navigable condition from its mouth to the city of Macon is contained in Mr. J. L. Van Ornum's report on the survey of the Ocmulgee River, accompanying my report of February 5, 1890, to which I would respectfully refer. It is impossible to make an accurate

estimate of the increased commerce that would follow such improvement. But remembering that new boats are to be added to the Lumber City and Hawkinsville lines, that citizens of Macon await the opening of the river to establish a line of steamers to the coast, that more frequent trips can be made and larger cargoes carried, and that a new region between Hawkinsville and Macon will become tributary to the river, it is not an extravagant estimate to say that the commerce of the river will be increased 100 per cent. of its present value.

MISCELLANEOUS.

Water-gauges were read at Macon, Abbeville, and Lumber City until June 1, 1890, when the exhaustion of the appropriation necessitated their suspension.

The work is located in the collection district of the port of Brunswick, Ga. Darien is the nearest port of entry. Amount of duties collected in 1889, $8,933.66. Sapelo Light is the nearest light-house, and Forts Oglethorpe and Pulaski are the nearest forts.

Since the existing project for improving the Ocmulgee River was adopted the following appropriations have been made for the work:

August 14, 1876	$15,000	July 5, 1884	$3,000
June 18, 1878	15,000	August 6, 1886	7,500
March 3, 1879	7,000	August 11, 1888	15,000
June 14, 1880	7,000		
March 3, 1881	5,000	Total	79,500
August 2, 1882	5,000		

The total expenditure to June 30, 1890, including all outstanding liabilities, amounted to $79,390.73.

As outlined in my project of February 5, 1890, it is proposed to expend any funds which may become available in the removal of obstructions and in the improvement of the shoals in the river between Macon and the mouth.

The sum of $50,000 can be economically and advantageously expended during the coming year. No permanent improvement can be effected, as new obstructions, caused by logs and snags, form during every high-water season. They should, however, become fewer in number each year. From $1,000 to $5,000 will be required for the annual maintenance of the completed work. The work of removing obstructions has been in the local charge of Mr. F. C. Armstrong, assistant engineer, whose report is appended hereto.

There is also appended my report upon the survey of the river, dated February 5, 1890, and printed as House Ex. Doc. No. 215, Fifty-first Congress, first session.

Money statement.

July 1, 1889, amount available		$11,518.30
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$11,273.35	
July 1, 1890, outstanding liabilities	135.68	
		11,409.03
July 1, 1890, balance available		109.27
Amount appropriated by act of September 19, 1890		30,000.00
Amount available for fiscal year ending June 30, 1891		30,109.27
Amount (estimated) required for completion of existing project		180,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		50,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

REPORT OF MR. F. C. ARMSTRONG, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., June 30, 1890.

SIR: Operations on the Ocmulgee River (1889–'90) were confined to snag-work and removal of overhanging trees.

In 1888–'89, the river had been cleared of the worst obstructions from the Forks (0) to Rocky Creek (39). At this point the snag-boat *Ocmulgee* took up the work, and from July 1 to December 21, 1889, removed the worst obstructions between here and Abbeville (93½) a distance of 54½ miles.

From January 10, to March 18, 1890, the snag-boat *Toccoa* worked from the Forks (0) to Hawkinsville (133), but the most important work done was between Abbeville (93½) and Hawkinsville (133), a distance of 39½ miles. This reach is less obstructed by snags than the river below, which is generally the case where there are rock shoals.

From July 1, to December 18, 1889, the steam-hoister removed overhanging trees from Hawkinsville (133) to Rocky Creek (39), a distance of 38 miles. The trees were all pulled back by hand, as the machinery of the steam-hoister was disabled by age.

A summary of the work done by the several parties is here given, as is also a detailed statement of the locality of snag-work.

The snags and overhanging trees reported as over 6 inches ran as high as 60 inches, and 18 inches would be an average for snags. Snags were removed entire; no cutting was done. Probably as large a one as has been handled was 110 feet long, 2 feet outer and 4½ feet inner diameter, with earth hanging to roots. I estimated the weight of it as 30 tons.

Detailed statement of work done to date.

Period.	Snags.		Stumps.	Overhanging trees.		Trees girdled.	Logs cut up on bank.	Cubic yards of rock removed.	Cubic yards of dirt removed.
	Over 6 inches.	Under 6 inches.		Over 6 inches.	Under 6 inches.				
1877 to 1889: (Report Chief of Engineers, for 1889) ..	5,749	.....	.....	5,461	.....	186	87	359	1,869
1889–'90.....	1,424	405	127	3,410	4,273	615	25	.....	.....
Total work done to June 30, 1890	7,173	405	127	8,871	4,273	801	112	359	1,869

Two jetties at Tillman's Bar were constructed, 220 cords of brush, 80 piles and 291 cubic yards of rock being used in the work.

Summary of work done 1889–'90.

SNAG-BOAT OCMULGEE.

Date.	Total days worked.	Number of days removing obstructions.	Explosives used.	Snags.		Stumps.	Overhanging trees.		Trees girdled.	Logs cut up on bank.
				Over 6 inches.	Under 6 inches.		Over 6 inches.	Under 6 inches.		
1889.			*Pounds*							
July	27	26	.....	247	58	28	48	81	.....	.....
August.....	27	25	.....	174	76	8	30	129	.....	.....
September.....	25	24	7½	168	67	28	34	82	.....	.....
October.....	27	21	6	165	55	20	33	73	.....	.....
November.....	26	25	5	183	41	9	40	38	.....	.....
December	18	17	16	146	26	1	32	69	.....	.....
Total	150	138	34½	1,083	323	94	217	472	.....	.....

SNAG-BOAT TOCCOA.

1890.										
January	19	19	.....	115	30	8	119	99	.....	1
February	24	19	.....	134	25	23	109	86	.....	2
March	21	15	.....	62	25	2	85	57	.....	.....
Total	64	53	.....	311	80	33	3	242	.....	3

Summary of work done 1889'-90—Continued.

STEAM-HOISTER.

Date.	Total days worked.	Number of days removing obstructions.	Explosives used.	Snags.		Stumps.	Overhanging trees.		Trees girdled.	Logs cut up on bank.
				Over 6 inches.	Under 6 inches.		Over 6 inches.	Under 6 inches.		
1889.										
July		26					239	478		
August		26					779	738		
September		19					231	227		
October		21		6	1		539	716		
November		26		18			817	1,042	568	16
December		15		6			275	358	47	9
Total		133		30	1		2,880	3,559	615	25
Grand total	214	324	34½	1,424	404	127	3,410	4,273	615	28

Summary of work by localities.

SNAG-BOAT TOCCOA.

Locality.	Distance above forks.	Snags.		Stumps.	Overhanging trees.		Logs cut up on bank.	Explosives used.
		Over 6 inches.	Under 6 inches.		Over 6 inches.	Under 6 inches.		
	Miles.							*Lbs.*
Oakey Bluff Reach	2	4			1	4		
Camp Stave	7	7		1				
Hubbard Shoal	13½	8		1	31	32	1	
Dent's Landing	14½	1			18	26		
McRae Landing	15–16½	6						
Skipper's Landing	17½	3	2		5	4		
Owl Head	19	1			3	7		
Above Braddock's Landing	29	2			18	4		
Mosquito Point	31	2			1	5		
Ashley Old Field	32½	1	3					
Above Scupper Bluff	34¼	1						
Ashley Cut	37¼	2		2				
Bear Lake Landing	38	2						
Rocky Creek	39	1						
Coffee New Ground	41–43	14	2		1			
Lampkin Lake	47	1						
Above Blackshear Cut	48½	40	15	2	25	12	1	
Jacksonville	51	22	8	1	4			
Mobley's Bluff	54				4			
Fodderstack Cut	59½	6	2		1			
Old River	63	6	3		5			
Yellow Bluff	64	9	1	2	11	5		
Brown Timber Landing	83½				12	12		
S., A. and M. Rwy. Bridge	94		1		53	29		
Yellow Bluff	95	1	2					
Half Moon Landing	97	13	1			3	1	
Con Face	102¼	15	5	16	14	20		
Below McDuffie's Timber Landing	102¾	30	5		8	4		
Acorn Landing	106				24	24		
	115½	24	3	1	15	17		
Boseman's Sand Bar	121⅓	21	2	2	31			
Seven Sycamores	127	68	25	5	28	34		
Total		311	80	33	313	242	3	

Summary of work by localities—Continued.

SNAG-BOAT OCMULGEE.

Locality.	Distance above forks.	Snags.		Stumps.	Overhanging trees.		Logs cut up on bank.	Explosives used.
		Over 6 inches.	Under 6 inches.		Over 6 inches.	Under 6 inches.		
Above Rocky Creek	39¼	22	1	.....	.....	.....	.....	.....
Jersey Lake	40	14	3	.....	15	24	.....	.....
Above Jersey Lake	40¼	9	.....	.....	5	8	.....	.....
Below Coffee New Ground	40¾	26	6	.....	2	.....	.....	.....
Do	41	10	1	.....	.....	2	.....	.....
Above Coffee Bluff	43	10	1	.....	4	12	.....	.....
Above Barrows' Bluff	44¾	20	6	.....	.....	.....	.....	.....
Swain's Cut	48¼	24	8	1	6	23	.....	16
Below Jacksonville	49¼	2	.....	15	7	5	.....	7½
Above Jacksonville	50¾	10	3	1	.....	.....	.....	.....
	51¼	14	6	.....	5	40	.....	.....
Big Eddy	51½	32	27	9	17	25	.....	.....
Moore's Landing	52¼	29	8	2	.....	.....	.....	.....
Below Sturgeon Creek	55½	28	6	.....	.....	1	.....	.....
Do	55¾	5	.....	1	.....	.....	.....	.....
Sturgeon Creek	56¼	13	3	.....	4	.....	.....	.....
Above Sturgeon Creek	56½	8	1	.....	.....	.....	.....	.....
Do	56½	33	12	1	2	16	.....	.....
Dick Swift	57½	60	21	2	20	42	.....	.....
Below Dominy's Landing	57¾	29	13	1	.....	.....	.....	.....
Do	58	28	18	1	9	31	.....	.....
Do	58¼	29	1	.....	10	70	.....	.....
Above Dominy's Landing	59	42	23	2	4	16	.....	.....
Paramore's Old Field	59½	31	7	.....	5	9	.....	.....
Fodderstack Cut	59½ 60½	27	8	8	1	.....	.....	.....
Below Lumpkins' Old Field	61	149	34	16	27	37	.....	.....
Above Lumpkins' Old Field	62	25	7	4	5	20	.....	.....
Do	62½	19	6	3	1	.....	.....	.....
Do	62¾	13	3	.....	.....	.....	.....	.....
Do	63	7	.....	1	1	.....	.....	.....
Do	63¼	8	2	2	2	13	.....	6
Do	63½	8	3	.....	.....	.....	.....	.....
Sycamore Cut	63½	25	12	2	16	18	.....	.....
Below Yellow Bluff	63¾	11	12	.....	.....	.....	.....	.....
Above Yellow Bluff	64	8	3	4	3	12	.....	.....
Below T. L. Wilcox	65	10	1	1	.....	.....	.....	.....
Above Old Steam Mill	67½	2	1	.....	.....	.....	.....	.....
Do	68	8	4	1	.....	.....	.....	.....
Do	68¼	14	4	.....	.....	.....	.....	.....
Do	68½	8	2	.....	.....	.....	.....	.....
Do	69	6	1	2	.....	.....	.....	.....
Do	69¾	8	4	.....	5	10	.....	.....
Above Tiger Leap	70	9	1	1	.....	.....	.....	.....
Above Blackseed Cotton Patch	70¼	16	5	1	.....	.....	.....	.....
Above Ely Landing	71¼	8	4	.....	.....	.....	.....	.....
Hollingsworth Ferry	72	8	.....	.....	3	.....	.....	.....
Spring Lake Bt	73	5	.....	3	7	11	.....	5
Above Spring Lake	73½	6	1	1	.....	.....	.....	.....
Above Wilcox Lake	75	8	2	1	.....	.....	.....	.....
Above Sydney Cut	75¾	16	5	.....	1	7	.....	.....
Mossy Log	77	13	3	2	2	.....	.....	.....
Above Suckout	82	7	.....	2	5	7	.....	.....
Do	83	5	.....	.....	1	.....	.....	.....
Below Round Tree Ferry	83¼	10	3	.....	.....	.....	.....	.....
Do	83½	9	2	.....	.....	.....	.....	.....
Above Round Tree Ferry	83¾	9	2	.....	.....	.....	.....	.....
First Henly Point	85	4	.....	.....	3	3	.....	.....
Second Henly Point	85¼	8	.....	.....	3	5	.....	.....
Below Henly Landing	85½	6	2	.....	3	.....	.....	.....
Upper Henly Point	86¼	15	6	.....	5	5	.....	.....
Above Wilcox's boat-yard	88½	8	3	.....	1	.....	.....	.....
Above Jordan's Bluff	91	16	2	.....	8	.....	.....	.....
Stadem's Shoals	92	13	4	.....	.....	.....	.....	.....
Total	.....	1,083	327	94	207	472	.....	34½

The year 1889–'90 was very favorable for snag-work, the stage of water averaging 4 feet above low.

The river is in a fair condition as regards snags, from the Forks (0) to Hawkinsville (133), but a snag-boat can be profitably employed for the entire year in this ter-

ritory. The work will consist in removing obstructions from points already worked, but from where only the worst have been taken. The snag-boat should commence at the Forks and work to Hawkinsville, removing those obstructions complained of, and then work down-stream and *clean* each bight.

If the river above Hawkinsville is to be improved, a bank party should be put on at Macon before the snag-boats are required, in order to remove trees dangerous to upper works.

When the snag-work is finished there are several places where cuts should be made or prevented. The work is necessary, but will require the services of a snag-boat, and until the snags are removed they are the more important.

The sloughs around the following points, being incipient cut-offs, should be closed.

Locality.	Above Forks.	Locality.	Above Forks.
	Miles.		*Miles.*
Owl Head	19	Henley's Points	85
Ruben's Cut	35	Switches Trail	96
Fodderstack Cut	60	Above Atkin's Shoal	94
Mossy Log	77	Cow Face	102
Big John Suck	82		

Cut-offs should be made at Tiger Leap (69¾), and above Hollingsworth Ferry (72¾).

The present works at Tillman's Bar (5½) should be improved by spur-dikes on left bank and bank revetment on right.

The other shoal places can probably be further improved by further snag-work.

A rock party should be put on at Hawkinsville, and gaps cut in the worst shoals, viz, Seven Sycamores (127), Davis (110½) and Stadems (92). If the funds would permit, all the shoals mentioned in the Report of the Chief of Engineers, 1889, should be included.

The bridge of the East Tennessee, Virginia and Georgia Railway at Lumber City, (12) is being rebuilt and will no longer be an obstruction. The bridge of the Savannah, Americus and Montgomery Railway at Abbeville (93½) is provided with a satisfactory draw.

The following is a list of boats plying on this river:

[C runs to coast. A runs to coast, connecting with Savannah, Americus and Montgomery Railway, at Abbeville. L local feeder to East Tennessee, Virginia and Georgia Railway at Lumber City. H local feeder to East Tennessee, Virginia and Georgia Railway at Hawkinsville.]

Name.	Tonnage.	Route.	Name.	Tonnage.	Route.
Ida	296	L.	Abbeville	240	A and C.
Tommie	180	L.	J. W. Sweeney	240	A and C.
Lumber City	227	L.	J. C. Stewart	129	H.
Swan	193	A.	Abbe*	110	H.
Americus	240	A.	New South	.....	H and A.

* Sunk (about 121½ miles).

The Savannah, Americus and Montgomery Railway, late Americus, Preston, and Lumpkin Railway, have discontinued their boats to the coast, having made connection with the Georgia Central at Sterling. The *Abbeville* and *Sweeney* have been chartered and are running to the coast independently. The *New South* had been connecting with the East Tennessee, Virginia and Georgia Railway at Hawkinsville, but is now connecting with the Savannah, Americus and Montgomery Railway at Abbeville.

The following freights were carried by these boats from July 1, 1889, to June 30, 1890;

Articles.	Quantity.	Weight.
		Tons.
Rosin.....barrels..	75, 280	18, 820
Spirits of turpentine .....do....	14, 131	3, 533
Cotton.....bales..	2, 385	596
Guano.....tons..	2, 350	2, 350
Merchandise .....do....	6, 365	6, 365
Total	.....	31, 664

Forty million feet of lumber were also rafted.

The snag-boat *Ocmulgee* was in charge of overseer J. D. Robeson and J. G. Walker; the *Toccoa* was in charge of overseers W. A. Dayton and J. D. Robeson, and the *Steam Hoister* was in charge of foreman Martin McGuffog.

All distances given are from the survey of 1889.

Very respectfully, your obedient servant,

F. C. ARMSTRONG,
Assistant Engineer.

Lieut. O. M. CARTER,
Corps of Engineers, U. S. A.

O 8.

IMPROVEMENT OF BRUNSWICK HARBOR, GEORGIA.

About 2 miles above the city of Brunswick Turtle River is divided by Buzzard's Island into two branches, the smaller one, flowing to the eastward of the island and upon which the city of Brunswick is situated, being known as East River, the other retaining the name of Turtle River. These streams unite again about 1½ miles below the city to form Brunswick River. The lower part of East River forms what is known as the harbor of Brunswick. Operations for the improvement of this harbor have been carried on in accordance with a project of improvement prepared by General Gillmore, the officer then in charge, and printed as Appendix M 12, Annual Report of the Chief of Engineers for 1886. This project is an enlargement and modification of a previous one submitted by the same officer and printed as Appendix J 7, Annual Report of the Chief of Engineers for 1880.

For a special report of past work see page 1047, Annual Report Chief of Engineers for 1888.

ORIGINAL CONDITION.

Turtle and Brunswick rivers have low-water depths of from 4 to 6 fathoms. Over the shoal in the East River, in front of the city, there was, when the existing project of improvement was adopted, a low-water depth of only 1½ fathoms. The mean rise and fall of tide is about 6.8 feet.

PLAN OF IMPROVEMENT.

The following comprise the main features of the plan of improvement:

(1) A training-wall, projecting from the most easterly point of Buzzard's Island and located approximately parallel to, and 1,000 feet or less distant from, the opposite shore of East River.

(2) A low dam across Turtle River, extending obliquely up-stream from the upper end of Buzzard's Island to the opposite shore of Blythe Island.

(3) Short spur-jetties in the lower part of East River.

(4) Dredging in the vicinity of Turtle River Dam and on the shoal in the lower part of East River.

The training-wall and spurs were to be constructed of Palmetto cribs loaded with stone, or of successive courses of log and brush-mattresses loaded with riprap stone. The works were intended to establish and maintain a 15-foot low-water channel across the shoal in East River. The cost of the original project was estimated at $73,187.50, and as modified at $190,000.

In 1836 an appropriation of $10,000 was made for the removal of the shoal in East River. Since the adoption of the existing project six appropriations have been made by Congress for the work, aggregating $92,500.

The project of improvement and estimate of cost were based upon insufficient data and need revision.

SUMMARY OF OPERATIONS PRIOR TO JULY 1, 1889.

A training-wall was constructed, springing from a point on the eastern side of Buzzard's Island, and extending N. 77° 30′ E. 335 feet; thence S. 14° 30′ 650 feet; thence S. 12° E. 3,549 feet to its present end.

The return work (with the exception of a shore extension 35 feet in length, built of log mattresses) and 780 feet of the main training-wall were constructed of palmetto cribs; the rest of the training-walls, 3,419 feet in length, of double raft mattresses loaded with riprap stone. Forty-nine cribs were used, 14 of which are in the return work. Each crib is from 20 to 25 feet in length and from 9 to 13 feet in width. The cribs were filled with brush and dredge material capped with stone, and rose from the bottom to the level of mean low water.

The double raft mattresses are from 30 to 40 feet wide, from 3 to 4 feet thick, and are loaded with about 12 inches of stone. In raising to a higher level the work already done, ordinary log and brush mattresses from 15 to 30 feet in width and loaded with from 4 to 8 inches of stone were used.

The old palmetto crib-work being too narrow to build upon, foundation courses of mattresses 30 feet wide were laid behind these cribs and close against them. Upon this foundation courses of mattresses 20 feet in width were laid until the work was raised to the level of the old cribs. The next course then overlapped the old crib-work, and upon this new crest mattresses of from 15 to 20 feet in width were laid. Along the return face and at the angle point apron-mattresses were laid on the channel side of the work to guard against scour. The return face was brought up to mean high water, and the training-wall to 4 feet above mean low water at the angle, gradually sloping down to the level of low water at a point 780 feet beyond.

In 1889 work was resumed, the crest being brought up with brush fascines loaded with riprap stone to about 5.5 feet above mean low water. There were used in the work during the year 2,318.88 cubic yards of fascines and 369.30 cubic yards of stone.

Dredged cuts from 80 to 100 feet in width and from 14 to 15 feet deep at mean low water were made at various times across the shoal. The material removed consisted of a mixture of sand, loam, and clay, and aggregated 171,298.67 cubic yards.

Up to July 1, 1889, the total expenditure for the work, including outstanding liabilities, amounted to $111,706.74.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

Dredging was carried on under the existing contract with Mr. P. Sanford Ross until September 10, 1889, when operations were suspended on account of the exhaustion of funds. During the year 29,096.27 cubic yards were removed.

Jetty work under the existing contract with Mr. Chas. C. Ely was carried on during July and August, 1889, when, owing to the exhaus-

tion of funds, operations were suspended. The work done consisted in raising the existing training-wall with alternate layers of brush fascines and stone. The crest was brought up to about 5.5 feet above mean low water for a distance of 1,050 feet, measured from the return angle of the work. In the execution of this work there were used 3,714.36 cubic yards of brush fascines and 619.48 cubic yards of stone. The survey of the harbor was completed.

CONDITION OF WORK JUNE 30, 1890.

An examination of the work was made during the latter part of June, 1890. The training-wall is in good condition, very little settlement having taken place during the year. The dredged cut has held well, the shoalest soundings showing a depth of 14.4 feet in the channel.

COMMERCE AND NAVIGATION.

The importance of the city of Brunswick as a sea-port has increased with remarkable rapidity during the past ten years. The population has increased from 2,891 in 1880, to about 12,000 in 1890. Taxable values have increased during the same period from $1,300,000 to $6,000,000. The naval stores business, begun here in 1875, reached over $1,000,000 in 1889. Lumber shipments increased during the same period from 37,000,000 to over 100,000,000 feet. Cotton shipments of 4,000 bales in 1884–'85 have reached 200,000 bales in 1889–'90. Between 80 and 90 per cent. of the total trade of Brunswick is dependent on water carriage. Two railroads terminate here, the East Tennessee, Virginia and Georgia Railway reaching with its connections the north and northwest, and the Brunswick and Western Railway extending across Georgia into Alabama and beyond.

The following lines of steamers are established:

Brunswick to New York, one steam-ship per week.
Brunswick to Savannah, two steamers per week.
Brunswick to river points, fourteen steamers per week.

Besides these, a large fleet of foreign and coastwise sail and steam-vessels engage in the Brunswick trade, which consists principally of shipments of cotton and naval stores.

Shipments—foreign and coastwise.

Articles.	1888.			1889.			1890 to May 1.		
	Amount.	Value.	Tons.	Amount.	Value.	Tons.	Amount.	Value.	Tons.
Cotton .....bales..	82,471	$4,373,291	20,618	171,607	$8,117,126	42,902	50,521	$2,365,007	12,620
Rosin .....barrels..	195,000	390,000	24,375	190,000	380,000	23,750	96,491	193,922	12,061
Turpentine .....do..	57,133	677,033	13,134	45,000	787,500	10,345	12,606	226,914	2,960
Lumber ..... M feet..	88,274	1,182,985	214,027	110,000	1,540,000	266,200	62,937	888,118	152,394
Cross-ties.....Number..	159,000	60,000	15,000	204,000	81,600	20,400	140,000	,000	14,000
Miscellaneous.....tons..	316	7,905	316	1,132	28,289	1,132	1,117	27,936	1,117
Total.....	.....	6,691,214	287,470	.....	10,934,515	364,729	.....	3,757,987	195,152
Estimated receipts by water, foreign and coastwise.	.....	2,937,426	117,500	.....	3,783,000	151,300	.....	1,575,000	63,000
Total commerce....	.....	9,628,640	404,970	.....	14,717,515	516,029	.....	5,352,897	258,152

These figures show an increase of 50 per cent. in the trade of 1889 over that of 1888. An estimate based on the shipments for the first five months of the present year indicates that the commerce of 1890 will exceed that of 1889 by at least 25 per cent. Persons interested in the trade of Brunswick estimate that owing to past works of improvement in the harbor freight rates have been reduced from 18 to 20 per cent., and that if the improvements were completed according to the existing project the total volume of trade would be increased 200 per cent.

MISCELLANEOUS.

The work is located in the collection district of Brunswick, Ga. Amount of duties collected in 1889, $8,933.66. St. Simon's is the nearest light-house, and Fort Clinch, Fla., the nearest fort.

Since the work of improvement was begun the following appropriations have been made:

By act of Congress approved—	
March 3, 1879	$20,000
June 14, 1880	10,000
March 3, 1881	5,000
August 2, 1882	25,000
July 5, 1884	10,000
August 5, 1886	22,500
August 11, 1888	35,000
Total	127,500

The total expenditures to June 30, 1890, including all outstanding liabilities, amounted to $127,457.73.

It is proposed to expend any funds which may become available during the year in raising the training-wall, in dredging, and in making further surveys, when, after the necessary data have been obtained, the project of improvement can properly be revised.

The sum of $62,500 can be economically and advantageously expended during the coming year.

Money statement.

July 1, 1889, amount available	$15,793.26
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	15,750.99
July 1, 1890, balance available	42.27
Amount appropriated by act of September 19, 1890	35,000.00
Amount available for fiscal year ending June 30, 1891	35,042.27
Amount that can be profitably expended in fiscal year ending June 30, 1892 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	62,500.00

SURVEY OF BRUNSWICK HARBOR, GEORGIA.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., June 30, 1890.

GENERAL: Operations for the improvement of Brunswick Harbor have, up to the present time, been carried on in accordance with a project of improvement prepared by General Q. A. Gillmore, of the Corps of Engineers, and printed as Appendix M 12, Annual Report of the Chief of Engineers for 1886. With a view to the revision of this pro-

ject a survey of the harbor was executed under my direction in 1888, 1889, and 1890 by Mr. Milnor P. Paret, assistant engineer, who has himself reported exhaustively upon the methods employed and the work done. The more important part of the latter consisted in—

1. A triangulation.
2. Soundings in East and Turtle Rivers.
3. Location of shore-lines.
4. Tidal observations.
5. A line of levels connecting tide-gauges.
6. Gauging with current meters at four places.

The triangulation, soundings, and location of shore-lines extend over the entire length of East River and well into Turtle and Brunswick rivers, and their results are rendered by Mr. Paret on a map drawn in two sheets on a scale of $\frac{1}{2400}$

The main part of the tidal work consisted in observations at the following three points:

1. McCullough's Wharf, near the lower entrance of East River.
2. Penniman's Wharf, near the confluence of East River and Academy Creek.
3. A point in Turtle River immediately above the upper mouth of East River.

At Penniman's Wharf two months' continuous observations were taken in 1889, and from a comparison of these with the simultaneous record of the self-registering tide-gauge at Fort Pulaski, Savannah River, reliable means of high and low water were obtained, while the mean data for the other two gauges were found from a series of simultaneous observations made on them and on the Penniman's Wharf gauge. The results obtained in this way are embodied in the following table, all heights having been referred to mean low water at McCullough's Wharf.

Tidal data in East and Turtle Rivers, Brunswick Harbor.

Station.	Mean semi-tidal interval of—		Mean duration of—		Reading of—		Mean rise and fall.
	High water.	Low water.	Fall.	Rise.	High water.	Low water.	
	h. m.	*h. m.*	*h. m.*	*h. m.*			
McCullough's	8 39	14 53	6 14	6 11	7.59	0.00	7.59
Penniman's	8 50	14 52	6 02	6 23	7.69	—0.05	7.74
Turtle River	8 55	14 57	6 02	6 23	7.82	—0.07	7.89

Besides the above tidal work the usual observations were made while current measurements were in progress, and from these data it appears that in the entire region covered by the survey the change of current from ebb to flood takes place either at the time of low water or somewhat before it, while the change of current from flood to ebb takes place from twenty-five to fifty minutes after high water. We consequently find a long duration of flood current and a short duration of ebb current. In East River, for instance, we have—

Mean duration of flood current ..... $7^h\ 12^m$
Mean duration of ebb current ..... $5^h\ 13^m$

As a consequence of the change of current taking place almost at the time of low water, we do not find in Brunswick Harbor that great difference between the mean elevation of surface during ebb and during flood flow that we find in all streams carrying a great volume of fresh

water, where the current always changes considerably after low water stand. The following relations were found in this respect:

Mean elevation of surface above mean low water.

	During mean—	
	Flood flow.	Ebb flow.
	Feet.	*Feet.*
Brunswick River	4.44	3.32
East River	4.19	3.72
Academy Creek	4.35	3.84

Gauging was done in Brunswick River immediately below the lower mouth of East River and in East River and Academy Creek immediately above the confluence of both. The work was carried out rapidly and has rendered approximate results only. The following volumes, corrected to tide were found:

	Ebb.	Flood.
	Cubic feet.	*Cubic feet.*
Academy Creek	66,000,000	84,000,000
East River	230,000,000	291,000,000
Brunswick River	3,410,000,000	3,590,000,000

The excess of flood volume over ebb volume at the Brunswick line may be due to the flow through Jointer's Creek and through the channel between Blythe's and Colonel's islands; but inasmuch as the difference amounts to only 5 per cent. it may also be due to errors of observation.

The excess of flood volume in Academy Creek, and in fact the excessive size of both volumes as compared with the tidal prism of the Creek proper (which is scarcely more than 200,000 cubic feet), is possibly explained by great areas of low lands on both banks, which are overflowed at high water and which may partly drain into Turtle River direct on the ebb tide.

The excess of flood volume in East River will be discussed further below:

In order to deduce from the volumes given above mean ebb and flood velocities in East River and in Brunswick River, we have to consider the following quantities:

	Mean arears of—	
	Mean ebb outflow.	Mean flood inflow.
	Squarefeet.	*Squarefeet.*
East River at Penniman's	15,400	15,700
East River 2,100 feet below upper end jetty	12,700	13,200
Brunswick River below East River	94,400	99,000

The volume of the tidal prism contained between the lower point in East River and the lines gauged in Academy Creek and East River may be put at 52,000,000 cubic feet; duration of ebb and flood in Bruns-

wick River at $5^h\ 19^m$ and $7^h\ 6^m$ respectively; the same durations for East River as given above.

From these values, in connection with the volumes given, we obtain the following mean velocities:

Velocities, v, of mean ebb and flood currents in Brunswick Harbor.

	Feet per second.	
	Ebb.	Flood.
East River at Penniman's	1.02	0.93
East River, 2,100 feet below upper end jetty	1.44	1.26
Brunswick River below East River	1.88	1.42

DEDUCTIONS.

Having in the above given a summary of the results of the recent survey, the general condition of affairs at Brunswick Harbor, as far as the immediate needs of navigation are concerned, may be given as follows:

The water in East River along the city front is good as low down as Cook's Wharf, where the 15-foot mean low-water curve terminates. The object of all work of improvement has been to connect the lower end of this 15-foot curve, by means of an equally deep cut with the deep water of Brunswick River, and to secure the permanence of this cut by means of suitable works. Of these latter only the training-wall now in existence has been executed; but it should be mentioned that this has always been looked upon by the author of the plan of improvement as only a part of the entire works required to attain the object in view. A low dam across Turtle River extending obliquely up-stream from the upper end of Buzzard's Island to the opposite shore of Blythe Island, and the removal of the shoals now obstructing the upper mouth of East River, both with a view to divert a greater volume of water into the latter, have been designated as additionally necessary in order to secure the permanence of the cut. As a matter of fact, up to 1889 dredging had to be continuously resorted to, since the opening of the cut, in order to keep it clear. In 1889 the upper 1,000 feet of the training-wall were raised to about 5 feet above mean low water, and soundings taken this summer show that since then the dredged cut has stood well. As far as the lower work only is concerned, it would therefore now appear to be the proper course to let time decide whether the present favorable state of affairs will prove a permanent one or not, having at the same time the required means in readiness for further dredging, in case that should become necessary.

But besides the immediate needs of the lower improvement there is another point of view under which the subject should be discussed. Although the preponderance of the flood volume as found above for East River may, in part, have been caused by errors of observation, in work, which as stated above is only approximate, yet the difference seems to be too great to be ascribed entirely to this cause, and we must therefore, on the strength of the available evidence, deal with the fact that considerably more water passes through the upper mouth of East River into Turtle River than is returned in the opposite direction. The simultaneous observations of a complete tide, taken on May 10, 1890, at McCullough's, at Penniman's, and at the upper mouth of East River,

would even seem to indicate that in the latter half of the ebb there is a flow through the upper mouth of East River into Turtle River. According to them the elevation of surface for about an hour previous to low water is higher at Penniman's than at the upper mouth of East River, while for nearly two additional hours previous to low water the elevations of surface at both places are practically the same. The inference is that during all these three hours previous to low water there is a point of maximum elevation of surface somewhere between Penniman's and the upper mouth of East River from which the current flows in both directions. It should be added that this view of the matter is not borne out by the current observations. During the last three hours of ebb flow at the East River line the mean velocity there may be put at about 0.70 of a foot per second, which would render a volume of about 70,000,000 cubic feet, while the tidal prism of East River above the line, voided during this time, amounts to hardly more than one-third of this. The remaining two-thirds of the ebb discharge must therefore be supplied by a flow from Turtle into East River.

However this may be, it appears clear that the ebb currents in East River, and especially near its upper mouth, are weak, to which circumstance the extensive shoals in the latter region owe their existence. A comparison with Savannah River will make the unfavorable circumstances discussed here strikingly apparent. There, in Front River, through a cross sectional area of 9,500 square feet, we have an ebb discharge of 600,000,000 cubic feet, while at the upper mouth of East River, through an area of, say, 11,000 square feet, we have an ebb flow of only about 160,000,000 cubic feet. It must be added that the lower improvement can not but have exercised an unfavorable influence in the premises, as it can hardly be doubted that, in the absence of the projected additional upper works of improvement, the lower training-wall, while increasing slopes and currents in its own region, had had the effect of diminishing both in the upper parts of the river. It is, therefore, not surprising that a decrease of cross-sectional areas appears to be in progress, as will be seen from the following comparative data:

Mean low-water cross-sectional areas in East River.

No.	Areas.	1889.	1879.
		Square feet.	*Square feet.*
1	Near upper mouth (on shoal)	7,460	10,070
2	.....do	7,320	8,870
3	2,400 feet above Academy Creek	11,080	No data.
4	Near Wood's Wharf	13,550	15,480
5	Below Parker's Wharf	14,560	15,190
6	Above City Wharf	14,270	15,330

On account of the great depths along the city front no serious inconvenience to navigation has as yet resulted from this shoaling, but the important question arises whether the process still continues, and if so, whether the bars near the upper mouth may not finally grow to such an extent as to practically separate East River from Turtle River and to leave its flow dependent on its own tidal prism. It is safe to say that an approach to such a condition of things would be accompanied by a deterioration of the channel.

In view of the possible permanency of the lower cut, it would seem that on the above questions at present hinges the necessity of completing the works of improvement to the extent they were originally de-

signed. A definite reply to this question can be furnished only by further surveys, which should include an investigation of the supposed upper ebb-current as well as a repetition of the gauging of at least Academy Creek and East River. From a comparison of such future surveys with the present one it will then become apparent whether the shoaling is still going on to a dangerous extent, and on the basis of definite knowledge obtained in this way it will be possible to decide with certainty either for or against the construction of the dam across Turtle River, and the removal of the obstructions in the upper mouth of East River. Pending this decision no changes in the original estimates and plans for the improvement of Brunswick Harbor are recommended. Funds for executing the surveys for such dredging as may possibly become necessary to keep open the lower cut should be available, and the sum of $62,500 is asked for during the present fiscal year.

The report of Mr. Milnor P. Paret, assistant engineer, is transmitted herewith.

Respectfully submitted.

O. M. CARTER,
First Lieutenant, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. MILNOR P. PARET, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Fernandina, Fla., April 30, 1890.

SIR: I have the honor to present the following report of methods and results obtained in connection with the survey made in 1888 and 1889 of the harbor at Brunswick, Ga., in accordance with the following instructions received from you:

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., October 30, 1888.

SIR: You will at once proceed to make a hydrographic survey of Brunswick Harbor, Georgia, which will extend from Turtle River above the city of Brunswick to that same river below the city. The shore-lines of Turtle River will also be located as far up as the railroad wharves. Basess will be carefully measured with a steel tape, compared with standard, and the East River will be covered with a system of simple triangulation. The angles will be measured by repetition or by the lake-survey method. The error of closure of any triangle should not exceed fifteen seconds. Azimuth will be determined by at least one night's observations on Polaris at elongation. The triangulation will be adjusted, the geodetic positions of the triangulation points computed, and the plotting done on a scale of $\frac{1}{2400}$. Shore-lines and other topography will be located where practicable by stadia measurements, the details between the closely located points being carefully sketched in. The meandered stadia lines, whose azimuth will be frequently checked, will begin and close on triangulation points. The wharf-lines along the city front will be located by transit and steel tape. A line of accurate levels will connect the two mouths of East River, permanent B. M's being established at intervals along the line. Tidal observations will be taken at the lower and upper ends of the city wharves and at the upper mouth of East River, and the duration of stand; duration and direction of ebb and flood flow; range of tide at gauges; slope of water-surface of both rivers at various stages of tide, both ebb and flood; and rate of propagation of the tidal-wave will be determined. Soundings will be taken with an ordinary lead line, kept constantly wet while in use, and compared each day, before and after use, with a standard measure. At the end of each minute soundings will be located by two transits or by sextant and transit. They will be reduced to local mean low water before plotting. The direction of tidal currents will be determined by floats or loaded rods. Current velocities will be determined by double floats, loaded rods, or meters, preferably by meters, which will be carefully rated. Turtle River will be gauged above and below East River, East River just above the mouth of Academy Creek, and Academy Creek just above its mouth. Borings, extending to 20 feet below mean low water will be made in East River, and to 35 feet below mean low water in Turtle River near the upper

mouth of East River. Your field maps will be kept plotted to date, and you will submit the usual tri-monthly reports, giving in detail all work done both in field and office. Upon the completion of the work there will be submitted a detailed report giving all methods and results; tables and diagrams of wind movements (if such data can be obtained); a chart of the river; tidal diagrams; velocity curves; discharge cross-sections; slope profiles; diagram of borings, etc. You will make requisition on this office for such assistance, instrument, means of transportation, material, etc., as you may require for a prompt and vigorous prosecution of the work.

Very respectfully, your obedient servant,

O. M. CARTER,
First Lieutenant, Corps of Engineers.

Mr. MILNOR P. PARET,
Assistant Enyineer.

In obedience to these instructions I left Savannah, Ga., the same day for Brunswick, Ga., and having arranged preliminaries and collected a field party, active operations were commenced on November 5, 1888.

TRIANGULATION.

A base line AB, 2,176.877 feet long was laid off in the center of the Brunswick and Western Railroad track and near the lower end of the town.

Triangulation points were set on either side of Brunswick River below Buzzard Island; on each side of East River throughout; up Academy Creek about three-quarters of a mile, and on each side of Turtle River up to the "New Docks." These points are designated as follows: On the Brunswick side, beginning below as K 1, K 2, K 3, etc.; on Buzzard Island, beginning at Brandy Point as B 1, B 2, B 3, etc.; on the north side of East River as C 1, C 2, C 3, etc.; and on the west side of Brunswick and Turtle rivers as D 1, D 2, D 3, etc.

The majority of these points were set of necessity on the edges of the marsh, which forms the sides of the rivers. Such stations were formed by sinking by hand 3 by 4 inch scantling into the mud until they could be forced no further with 500 or 600 pounds pressure. From 12 to 16 feet was the depth reached. Around the center hub, which was left about half a foot out of ground, were sunk three such scantlings extending 2 or 3 feet out of ground and being well braced together. These were used for setting the transit on. Separate from these and slightly higher and farther from the center hub were sunk three other scantlings on which was built a platform for the transit man to stand upon.

At high water the marsh was covered with water to a depth of a foot or more, and the stations were set high enough to be above high water and also to enable the transit man to see over the marsh grass. Along the city front stations were set whenever practicable on the corner of wharves. Twelve or 14-foot poles with distinctive flags were set up at each station. These points were connected with the base line and all the angles of the triangulation measured by the repetition method. The greatest error was 38 seconds in triangle D 2, D 3, C 7, and the least error one second in the triangle K 6, K 7, B 4. The average error of closure of the triangles was about six seconds, and but one or two exceeded by a second or two the margin of fifteen seconds. The following triangles exceed the limit: B, A, B 2, by 21 seconds; B 3, B 4, K 6 by 17 seconds; B 6, C 2, C 3, by 19 seconds; D 1, C 5, D 2, by 23 seconds; and D 2, D 3, C 7, by 38 seconds. A great deal of difficulty was experienced in getting the triangulation to check out, owing to the fact that perfectly secure stations against tremor could not be built on the marshes, except by an expenditure of money inconsistent with the result to be derived. The transit used was graduated to thirty seconds and was No. 861 (Buff & Berger, makers). The error of closure in any triangle was eliminated by simply giving each angle such increment or decrement as local conditions would indicate as most probably correct, this being considered under the circumstances as more correct than "Pierce's Criterion," since the angles were never measured under the same physical conditions, and the instability of the station or force of wind generally located the probable error.

AZIMUTH AND MAGNETIC VARIATION.

Polaris was observed at western elongation for azimuth on the night of November 26, 1888, and in the following manner: A point was occupied on the top of a flat brick wall of a low building. This point was so situated that the star and one of our triangulation stations were nearly on line. Observation extended for about five moments on each side of the time of elongation, as many angles being read in this time as possible. Then, since the triangulation station was to the left of the star, the mean of the angles plus the azimuth of the star gave the azimuth of the line from the point occupied to the triangulation station. The increase or decrease in

the azimuth of the star for five minutes of time each side of elongation is too small to be appreciable, so no correction was applied. The next day the transit was set over the triangulation station observed, and the angle was measured between the point on the brick wall and another triangulation station. A great number of needle readings were taken at various stations where there was any liability to local attraction. From these the deduced magnetic variation was found to be 1° 41′ 7″ east. Table A accompanying the report gives these observations.

SOUNDINGS.

Lines of soundings were run across the rivers, and generally about 200 feet apart. Individual soundings on these lines were located every minute by either two transits, or transit and sextant. Time was kept by a chronometer in the sounding-boat, the watches of the transit men being set with the chronometer before starting work and compared again at the close of work. The sounding coming nearest the minute was located by signal from the sounding-boat. The recorder would raise a flag about ten seconds before the lead-line came plumb, and would drop the flag the second the line came plumb, the transit man taking angles to the leadline at that instant, noting first their time and then the angle. When the sextant was used the transit angle was taken to the sextant. The soundings were reduced to the plane of mean low water as found in 1883. In plotting, those soundings coming between instrumentally located ones, when of about an even depth, were spaced uniformly; when the depth varied materially the soundings were spaced proportionally to the time required to take them. When for any occasion there was cause to doubt the correctness of the soundings or of their positions, they have been omitted from the map, as tending to give unreliable information. The lead-line was marked in fathoms, feet and half feet, and was tested daily while wet, with a steel tape. The correction found was recorded and applied to the reduced soundings. Some 5,000 soundings were taken in all, representing about 40 miles of sounding lines run.

TIDE-GAUGE READINGS AND REDUCTIONS.

The tide-gauge observations began at McCullough's Wharf on November 7; at the Brunswick and Western Railroad (or Penniman's) Wharf on the 13th, and in Turtle River on the 17th of November. Day readings only were continued at the gauges with as much regularity as possible until December 18, when further work on this survey was postponed. The party was transferred to Fernandina, Fla., to take up the more pressing and important survey of Cumberland Sound, Georgia and Florida. In the spring of 1889 continuous day and night observations were taken for two months at the Brunswick and Western Railroad Wharf. A table giving the times and heights of all observed high and low waters and prevailing direction of winds has been formed and is shown in papers "C" of this report.

The Turtle River gauge was attached to a pile driven near the east shore of that river and just above the mouth of East River. The locality of each gauge is shown on the maps, and the computations of mean tidal data are submitted herewith.

The variation in the range of tides is considerable. Of those observed by us the lowest neap range was 4.1 feet and the greatest spring range 10.75 feet, the high waters ranging from 9.75 feet on the gauge to 6.7 feet, and the low waters between 2.9 feet above and 1.4 feet below the zero of the gauge. The relative directions of flood and ebb currents were found at various points by means of loaded rod floats. These directions are indicated on the large maps by means of arrows.

The ebb-tide floats in East River above and opposite the training-wall were run in July, 1889, when that year's work on the training-wall was about complete.

Diagrams 2 and 3 show all the complete flood and ebb tides which were observed simultaneously on the three gauges. The number of such curves is not sufficient, nor is there enough regularity or uniformity in those observed to obtain true mean tidal slopes.

TOPOGRAPHY.

The shore line was located by stadia measurements from the nearest triangulation station, details between such located points being carefully sketched in.

The wharf fronts and topography along Bay street, Brunswick, were generally located by off-sets at right angles, whenever possible, to the base line or its extension. Any short angle line was tied back into the base, and all measurements were taken with a steel tape. The marsh line has been shown on the maps as the high-water line. High-water line proper, except along the high land of the city front, would be indeterminate, as ordinary high water covers to the depth of a foot or more nearly all of Buzzard Island and the marshes which line throughout the shores of the river. The sounding lines determined the low-water line with considerable accuracy, as, when reduced to mean low water, they nearly all showed plus soundings at the shore ends.

WIND RECORDS.

The only information of any value relative to the winds that could be obtained was given me by the keeper of the Saint Simon's light-house, and are taken from his day log-book. The observations cover a period of fourteen months, from January, 1888, to March, 1889. The prevailing light winds seem to be from the west, and prevailing stiff winds from the east. More than 50 per cent. of the northeast winds are stiff. It seems rather remarkable that there should have been but two gales in a period of fourteen months. These records are found tabulated in papers "E," accompanying this report.

LEVEL-LINES AND BENCH-MARKS.

Starting from a bench-mark established during the survey of 1883, careful lines of check-levels were run between the gauges. The instrument was kept in as perfect adjustment as possible, the foresights and backsights being equalized, and the work was done only under the most favorable atmospheric conditions. Permanent gas-pipe bench marks were established near each tide gauge and at other desirable points. Their locality and elevation above mean low water are given on the large maps.

GAUGING.

Four channels or, more properly, rivers, were gauged, namely: Brunswick River, just below the mouth of East River; East River, just below the mouth of Academy Creek; Academy Creek, just above its mouth; and Turtle River, above East River. These sections are shown on diagram No. 4. The Brunswick River section has a width of about 4,200 feet, and an average depth of about 22 feet. The East River section has a width of 800 feet, and an average depth of 18 feet. Academy Creek section has a width of 500 feet and a depth of 8 feet. Turtle River has a width of 2,700 feet, and a depth of 22 feet. All of the above depths refer to mean low water.

Ranges were established on shore, plainly defining the directions of the sections, and repeated and careful lines of soundings were run on them at slackwater. These soundings being plotted on the map and transferred to cross-section paper, the most desirable positions for buoys were decided upon, and being plotted on the map, were placed in the field by being dropped from a boat on the established range, their distance from shore being determined cut-off angles, with a transit located at a convenient triangulation station.

There were five buoys placed on the Brunswick River section, three each on East River and Academy Creek, and six on the Turtle River section. The buoys were generally 2-gallon tin cans, anchored with stones or pieces of iron junk.

Two electric-current meters were used to obtain velocities. They were the stackpole propeller meters Nos. 1 and 3, the rating of which had been determined a short time previously on the Savannah River. There were two parties in separate boats, one with each meter, and as a rule, observations were taken by each on the same section and at the same time. Each party took observations at two adjacent buoys, although in some instances observations were continuous at one buoy. One ebb and one flood tide were observed at each buoy, and in some instances as many as two or three tides at the same buoy. In Academy Creek two ebb and two flood tides were observed; in East River, three ebb and two flood; in Turtle River, three ebb and two flood; and in Brunswick River, two ebb and two flood. The ranges of these tides varied from 6.3 feet to 10.9 feet.

A 40-pound anchor was used to hold the boat in place. It was dropped overboard from 50 to 100 feet above the section, according to the depth of water at the buoy. The boat then dropped back until it was made fast with its bow on the section range. A balance beam was arranged over the bow of the boat, through a pulley at the outer end of which was placed a line (window cord size) to which was attached a flat iron wheel weighing about 30 pounds. This wheel rested on the bottom, and the line attached being hauled taut and made fast to the balance frame, the latter took up the irregularities owing to any swell or pitching of the boat. This vertical anchor line passed through a short piece of gas-pipe on which was suspended the meter, and a copper chain graduated in feet and half feet was attached to the gas-pipe, by which the meter was raised and lowered to the desired depth. These two lines were managed by one of the boatman in the bow of the boat, and the wires were led conveniently aft, where the observer sat, and were attached to the battery and register.

Two methods of obtaining velocities were used. One was to lower the meter at an uniform rate from top to bottom, such rate being one-tenth of a foot per second or one fathom a minute, the register being read every minute. The other was simply to allow the meter to revolve for a certain time, one minute as a rule, at various successive depths. As a rule, two sets of observations were taken from surface to

bottom at any buoy before the boat was moved to the adjacent buoy. Careful gauge readings were always taken at the nearest gauge throughout the tide observed. The meter in its lowest position was .6 of a foot from the bottom, and in calm weather was generally brought to within a half foot of the surface. The computations of volumes and of velocities are submitted herewith.

VELOCITIES AND VELOCITY CURVES.

On pages 30 to 33, inclusive, of papers F, are shown for each tide and buoy observed the range of tide, greatest observed velocity, hours after slackwater and distance from surface, and total depth at which it occurred; also the greatest bottom velocity and time after slackwater at which it occurred. The greatest observed velocity occurred on the Brunswick River section at Buoy No. 5, ebb tide, with a range of tide of 8 feet, and was 4.45 feet per second. Diagram 7 shows surface, mid-depth, bottom and mean velocity curves for all tides and verticals observed. There are 151 such curves; they are plotted on cross-section paper; scale horizontal 1 inch = 1 hour, and vertical 1 inch = 2 feet per second. There is found to be almost sufficient uniformity between the mid-depth and mean velocity curves to warrant the possibility of quite accurately ganging such streams by simply observing the mid-depth velocities.

BORINGS.

There were 12 borings taken in all, their locations being as follows:
No. 1. About 60 feet below outer end of McCullough's Upper Wharf.
No. 2. About 500 feet off from McCullough's Upper Wharf.
No. 3. Near jetty and opposite McCullough's Upper Wharf.
No. 4. Near middle of stream opposite Cook's Wharf.
No. 5. About 300 yards below McCullough's Lower Wharf.
No. 6. About 500 feet west from No. 5.
No. 7. Just above middle of lower mouth of East River.
No. 8. In East River and just below upper end of Buzzard Island.
No. 9. In Turtle River about 300 feet off and above end of Buzzard Island.
No. 10. About 500 feet off west shore of Turtle River and northwest of Buzzard Island.
No 11. About 100 feet above No. 10.
No. 12. About middle of Turtle River and northwest from end of Buzzard Island.

These borings are shown on the maps by a series of small concentric circles; they were taken in the field in the following manner: A small scow, decked over, 10 feet wide by 18 feet long, was used from which to handle the boring apparatus. By laying a couple of four by six scantlings across the center of the scow and lashing them fast underneath, a platform about 4 feet square was rigged at one side of the scow and projecting out over the water. To hold the scow in position, three anchors were used, each weighing from 50 to 60 pounds; lines from two to three hundred feet long were attached to them. One was lead directly forward and one directly aft, being made fast at the centers of each end of the scow; the third anchor leading directly abreast from the center of the side opposite the platform. Three-inch iron pipe was used to take borings with, one length being 14½ feet, and there being five other lengths of 5 feet each. At the end of the long section six teeth were cut about 1½ inches deep, alternate teeth being bent slightly in and out. The anchors being run out, the scow brought into position and lines made fast, the pipe was put down between the sides of the scow and the platform; the pipe was then turned or screwed down by means of a pair of set tongs. These tongs had handles 3½ feet long and could be made fast to the pipe at any desired height by means of screw-bolts passing through both branches of tongs on opposite sides of the pipe. Cleats were tacked on the platform close up to the pipe to hold the latter in place.

At first, the men turning the pipe would put their weight on the tongs; when the boring went slowly 200 or 300 pounds of junk were slung over the pipe, and still later two or three men stood on or hung on to the weights; in this manner quite 1,000 pounds could be put on the pipe. Boring at any point ceased when the last twenty minutes turning made no appreciable gain or when the pipe jammed.

The depth of water alongside of the pipe was then taken, the time being noted for the tide-gauge correction, and the length of pipe below water-surface was measured. The position of the boring was located by the three-point problem, with the sextant. An iron cap was then screwed to the top of pipe, making as air-tight a joint as possible, with the view of holding the material in the pipe by means of the vacuum formed. The result was generally quite satisfactory in this respect. Diagram No. 8 shows all the borings and the material met with, in detail.

There seems to be a substratum of a hard, marl-like formation underlying certain localities of the territory surveyed. This formation was encountered in taking bor-

ings Nos. 1, 7, 8, and 9. At boring No. 1, at a depth of 11.5 feet. Borings Nos. 2 and 3 do not show marl, though going to a depth of 15 feet and 17.2 feet, respectively. Boring No. 4 does not show it, though going to a depth of 28.6 feet. Also at borings Nos. 5 and 6 it does not show at depths of 17.3 feet and 20.4 feet, respectively. It is interesting to note that the dredging inspector's notes of material encountered near borings Nos. 2 and 5 are substantially as found by us. Boring No. 7 shows this hard formation at a depth of 21.6 feet, but was of a much softer nature than that found at boring No. 1. Again, at boring No. 8, in the upper mouth of East River, it is found at a depth of 18.6 feet. The material met with here before reaching the marl is sand and mixed sand and mud, evidently all sedimentary deposit, which might easily be scoured out by increased tidal action.

MAPS.

These are in two sheets, the scale used being $\frac{1}{2400}$. On them are shown the soundings, shore-lines, general topography, including Bay street, Brunswick, and the cross streets leading up toward the town; the triangulation points, meridians and parallels of latitude, wharf-lines, etc. In addition to the high and low water lines are shown the 6, 12, 15, and 18-foot contours. The dredging range was located and is shown on the map. It is substantially the same as was used in the last dredging work done here. A dumping-ground was staked out in Brunswick River just above the mouth of Jointer Creek. A few sounding lines were taken here, with a view of a later examination to be made any time after dredging and dumping had ceased, to ascertain how the loosely-deposited material remained.

A comparison with the map of 1883 would indicate quite an apparent deepening of the whole channel between the jetty and the east shore. From Dexter's Wharf down to Jeter's Wharf, near and east of the lower end of the jetty, the shoal seems to be growing and moving down-stream. A great deal of muddy sediment seems to be washed from the shores of the marsh islands by storm waves at high tides and deposited in banks along the shores. Such mud banks are most apparent along the lower wharves of the town front. Vessels had long been in the habit of lying head or stern on the wharves, often being for weeks in the same place and most of the time hard aground, so that the current, instead of having free action for scour, was practically shut off entirely, the result being the mud banks and lumps referred to. In illustration of this point, the dredge having been allowed to do a day's private work on December 14, 1888, moved in and dug a hole at the stern of a vessel lying head on at Frierson & Co's Wharf. There were at the time about 5 or 6 feet of water at the vessel's stern. The dredging was done to a depth of about 20 feet, and sand was just touched at that depth, the rest of the material being all soft mud.

On sheet No. 2 of the large map I have sketched in closely from the Coast Survey chart, the lower end of the 18-foot curve of the bar making down the centre of Turtle River. The planes to which soundings are reduced are not likely the same on the two maps, but even allowing a very wide margin of difference, the bar is evidently moving down-stream rapidly, as indicated by the relative positions of the two 18-foot curves. The latter part of the field work of the survey was finished on the first of August, 1889. Owing to a press of more important surveys and the regular routine of construction work, nothing was done in the field (beyond some tidal observations in April and May, 1889) between the months of December, 1888, and June, 1889. The report is rendered as soon as it could be consistently with the proper performance of other duties.

I desire to recommend to your attention Messrs. Joseph Coulson, jr., and George F. Riggs, surveyors, and George Gammont, leadsman, as having rendered faithful and efficient services.

The following maps, diagrams, books, etc., accompany the report:

1. Two charts harbor at Brunswick, Ga., scale 1 inch 200 feet.
2. Eight sheets of diagrams giving tidal curves, slopes, borings, velocities, discharges, etc.
3. Papers A, B, C, D, E, F, and G. Tables and computations.
4. Fifteen books of tide records.
5. Three books of current observations.
6. Four books of transit notes.
7. Two books of soundings.
8. One book of compiled information notes.
9. One book of miscellaneous notes.
10. Sixteen specimens of borings.

Very respectfully, your obedient servant,

MILNOR P. PARET,
Assistant Engineer.

Lieut. O. M. CARTER,
Corps of Engineers, U. S. A.

REPORT OF MR. MILNOR P. PARET, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., June 30, 1890.

SIR: I have the honor to submit the following report of operations carried on during the fiscal year ending June 30, 1890, for the improvement of Brunswick Harbor, Georgia.

The current observations necessary to complete the survey of this harbor were taken in July, 1889; the report on the survey was rendered in April, 1890.

DREDGING.

Under an existing contract with Mr. P. Sanford Ross this work was continued during the months of July, August, and September, 1889. The unfinished third cut of the previous year, on which work was being done at the time of the last annual report, was completed, and an additional or fourth cut was made to the westward of those already dredged. This left a channel of 120 feet in width, having a depth of not less than 15 feet at mean low water. The length of the cut was 5,650 feet, and extended from the 15-foot contour opposite Cook'sWharf, to the same contour about opposite the lower end of the jetty. The depth before dredging may be said to have averaged about 11 feet. The material met with was coarse sand and shell with occasional streaks of mixed mud and sand. The dumping-grounds were in the same locality as last year, namely, on the west shore of Brunswick River and just above the mouth of Jointer Creek. Upon the completion of the fourth cut, the inspector sounded carefully over the dredged area and ascertained that no shoal places existed. Dredging was completed and the contract closed on September 10, 1889.

The following table gives the amount dredged monthly; the price per cubic yard was 21$\frac{1}{2\,5}$ cents.

Month.	Cubic yards removed.
1889.	
July	12,531.78
August	11,256.85
September	5,307.64
Total in present fiscal year	29,096.27
From last annual report	50,796.67
Total under the contract	79,892.94

JETTY WORK.

Work on the jetty continued during July and August, 1889, under the existing contract with Mr. Charles C. Ely. This work consisted in raising the existing training-wall by means of alternate layers of fascines and stone. The fascines were from 15 to 18 feet long and about 14 inches in diameter. They were placed at right angles with the course of the jetty, and after being well settled in place were loaded with from 6 to 12 inches of stone.

In this manner the training-wall was raised to a height of 5½ feet above mean low water and for a length of 1,050 feet, reckoning from the return angle southward.

At the lower end of the wall the work was rendered additionally strong by forming the fascines into mats and placing them so as to overlap and rack back in successive layers and this construction given a somewhat increased covering of stone.

The following table gives the amount of work done monthly; the price for stone being $3.41 per cubic yard and for fascines $1.34 per cubic yard.

Month.	Stone.	Fascines.
1889—	*Cubic yards.*	*Cubic yards.*
July	402.32	3,221.76
August	217.16	492.60
Total in present fiscal year	619.48	3,714.36
From last Annual Report	369.30	2,318.88
Total under the contract	988.78	6,033.24

Work was finished and the contract closed on August 9, 1889.

PRESENT CONDITION OF WORK.

An inspection made on June 10, 1890, shows the jetty as being in very good shape. As was to be expected, there is some slight settlement in places. This settlement is however, directly downward, and has not impaired either the strength or efficiency of the jetty. Several lines of soundings were run in the channel, from which we find that 14½ feet can be carried through at mean low water. The soundings taken vary from 14.4 feet to 17.3 feet, a large majority of them running over 15 feet.

Inasmuch as this examination was made nearly a year after the last dredging was done, and as no complaints have been entered relative to inadequate depth in the channel, it is quite gratifying to note that the channel has maintained itself for such a period. It would seem to indicate that the raising and extending of the jetty has had the desired effect of keeping the channel open by diverting an extra amount of ebb flow through it and in its direction.

It would be desirable to make a more extended examination than the funds and time allowed for the annual examination, and thus determine more fully the action of the jetty. Any farther extension of the jetty does not seem desirable until such an examination might prove its necessity. No immediate funds for dredging are required, though it would be well to have funds available for such work, as from past experience we are not able to count upon the channel remaining open indefinitely.

Very respectfully, your obedient servant,

MILNOR P. PARET,
Assistant Engineer.

Lieut. O. M. CARTER,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

Arrivals and clearances of vessels, and commerce, at Brunswick, Georgia, from January 1, 1878, *to December* 31, 1889.

ARRIVED.

Years.	Coastwise.			Foreign ports.						Total.		
				American vessels.			Foreign vessels.					
	No.	Tons.	Crew.	No.	Tons.	Crew.	No.	Tons.	Crew.	No.	Tons.	Crew.
1878.....	116	32, 584	850	36	10, 218	270	41	19, 008	493	193	61, 810	1, 613
1879.....	148	44, 397	1, 090	33	8, 235	232	40	17, 589	468	221	70, 221	1, 790
1880.....	271	77, 656	1, 892	36	11, 219	317	39	14, 996	432	346	103, 871	2, 641
1881.....	279	100, 451	2, 239	13	4, 174	98	63	30, 279	751	355	134, 904	3, 088
1882.....	335	123, 149	2, 659	7	2, 095	57	63	26, 958	694	405	152, 202	3, 416
1883	299	110, 302	2, 368	11	4, 814	107	87	40, 765	979	397	155, 881	3, 454
1884.....	239	88, 063	1, 893	10	4, 434	88	126	62, 818	1, 435	375	155, 315	3, 416
1885.....	242	93, 280	1, 928	10	3, 216	97	94	43, 284	1, 037	346	139, 780	3, 052
1886.....	229	88, 244	1, 751	7	3, 262	48	98	47, 798	1, 164	334	139, 304	2, 835
1887.....	194	86, 731	1, 625	8	3, 251	116	102	54, 537	1, 232	304	144, 519	2, 973
1888.....	821	290, 590	8, 619	9	2, 991	76	147	80, 330	1, 729	977	373, 911	10, 424
1889.....	220	92, 831	1, 764	20	10, 035	176	191	113, 757	2, 403	431	216, 623	4, 343

CLEARED.

1878	124	32, 767	874	28	9, 231	236	49	21, 218	550	201	63, 216	1, 660
1879	157	42, 345	1, 116	21	7, 172	172	47	21, 730	555	225	71, 247	1, 843
1880.....	270	78, 913	2, 010	14	5, 010	115	48	19, 970	550	332	103, 900	2, 675
1881.....	252	82, 155	1, 732	17	7, 218	156	87	42, 659	1, 014	356	132, 032	2, 902
1882.....	278	96, 170	2, 086	19	7, 761	170	101	48, 699	1, 139	398	152, 630	3, 395
1883.....	257	91, 036	1, 962	28	11, 268	240	124	55, 717	1, 369	411	158, 021	3, 571
1884.....	176	62, 927	1, 322	38	16, 209	335	148	70, 612	1, 633	362	149, 748	3, 290
1885.....	196	71, 345	1, 481	21	8, 696	190	135	62, 437	1, 456	352	142, 478	3, 127
1886	184	67, 020	1, 413	17	7, 528	159	117	56, 280	1, 305	318	130, 828	2, 877
1887.....	130	51, 305	958	5	5, 858	143	131	72, 894	1, 526	276	130, 057	2, 627
1888.....	785	266, 152	8, 240	13	4, 715	116	173	102, 360	2, 236	971	373, 227	10, 592
1889	169	65, 809	1, 273	11	4, 266	103	221	130, 919	2, 830	401	200, 994	4, 206

COMMERCE.

Years.	Value of exports.	Value of imports.	Total collection.
1878	$1,372,842	$400	$4,500.97
1879	1,394,401	3,197	5,644.33
1880	1,702,570	8,098	17,723.27
1881	2,230,000	4,377	29,305.30
1882	2,700,000	2,734	20,058.90
1883	3,437,000	3,093	24,911.61
1884	3,500,000	958	19,780.32
1885	3,063,960	4,008	3,939.27
1886	2,828,656	2,397	5,834.43
1887	4,121,660	*2,815,769	37,520.00
1888	7,552,025	*3,140,231	7,438.04
1889	7,894,281	6,557	8,933.66

*Coastwise and foreign.

Comparative statement of receipts and shipments of naval stores.

Years.	Receipts (barrels).						Shipments (barrels).							
	Stock on hand.		Receipts for year.		Total.		Coastwise and interior towns.		Foreign.		Stock on hand.		Total.	
	Rosin.	Spirits.	Rosin.	Spirits.	Rosin.	Spirits.	Rosin.	Spirits.	Rosin.	Spirits.	Rosin.	Spirits.	Rosin.	Spirits.
1880..	3,000	600	36,495	8,661	39,495	9,261	29,339	8,371	7,201	650	2,935	240	39,475	9,261
1881..	2,935	240	67,562	13,490	70,297	13,730	37,029	8,621	18,077	3,009	15,191	2,100	70,297	13,730
1882..	15,191	2,100	104,357	23,459	119,548	25,559	46,785	11,533	52,972	11,826	19,791	2,200	119,548	25,559
1883..	19,791	2,200	80,078	16,105	99,769	18,305	9,846	5,183	74,687	12,229	15,236	1,893	99,769	18,305
1884..	15,236	893	105,622	23,449	120,858	24,342	22,859	2,565	98,983	20,167	8,016	2,610	120,858	24,342
1885..	8 016	1,610	92,958	20,900	100,974	22,510	20,197	3,556	68,814	26,169	11,963	2,785	100,974	22,510
1886..	11,963	2,785	139,366	34,625	151,329	37,410	30,898	15,620	75,094	10,629	45,337	1,161	151,129	37,410
1887..	45,337	1,161	125,546	32,238	170,883	33,459	22,356	7,959	111,731	23,986	36,813	1,403	170,890	33,439
1888	27,098	2,420	140,820	37,643	167,918	40,063	29,746	8,339	120,159	27,901	18,013	3,823	167,918	40,063
1889..	.....	.....	186,000	45,000	.....	.....	17,753	6,389	152,394	29,560	31,869	2,259	202,016	38,708

O 9.

IMPROVEMENT OF JEKYL CREEK, GEORGIA.

Jekyl Creek forms part of the inside passage between Savannah River, Georgia, and St. John's River, Florida. It connects St. Simon's Sound and Brunswick River at the north with Jekyl and St. Andrew's sounds at the south. The creek is about 5 miles in length, is separated from the Atlantic Ocean by Jekyl Island, and debouches into Brunswick River about 6 miles from the town of Brunswick, Ga.

Operations for the improvement of this creek have been carried on in accordance with a project of improvement prepared by General Gillmore, the officer then in charge, and printed as Appendix N 10, Annual Report of the Chief of Engineers for 1888.

ORIGINAL CONDITION.

With the exception of two points the creek has ample widths and depths to accommodate the largest class of vessels that take the inside

route. About a mile from its northern end a shoal is found between the points where Lathram and Mud rivers enter the creek, and from the mouth of the creek to the deep waters of Brunswick River, in the bight formed by the southern shore of the latter, there is an extensive mud-flat. The lowest mean low-water depth across at the mouth of the creek was 3.7 feet. Across the shoal between Lathram and Mud rivers it was 3 feet. The mean rise and fall of the tide is 7.1 feet.

PLAN OF IMPROVEMENT.

The following comprise the main features of the plan of improvement:

(1) A training-wall at the mouth of the creek, designed to guide and concentrate the ebb currents across the mud-flats to the deep waters of Brunswick River.

(2) Closing Mud River by means of a dam at some suitable point, to prevent the escape of water through that branch at ebb tide.

(3) Dredging through the mud-flats at the mouth of Jekyl Creek and in the creek proper near the mouth of the river.

The training-wall and closing-dam were to be constructed of log and brush mattresses, brush fascines, and riprap stone below the level of low water; above that point stone alone was to be used. It was proposed to give the dredged channels a bottom width of 50 feet. The works were intended to establish and maintain a 7-foot low-water channel through the shoals. The cost of the project was estimated at $38,590. In the river and harbor act of August 11, 1888, the sum of $5,000 was appropriated for this improvement. This is the first appropriation ever made for this work.

SUMMARY OF OPERATIONS PRIOR TO JULY 1, 1889.

Dredging was begun on February 4, 1889, and terminated on account of the exhaustion of funds on March 19, 1889. During this period there were removed a total of 20,486.84 cubic yards, 12,546.33 cubic yards of which were removed from the bar outside of the mouth of the creek.

CONDITION OF THE WORK JUNE 30, 1890.

An examination of the work made during the latter part of June shows that the dredged cuts have maintained their depths fairly well. Six feet at mean low water can be carried through the channel over the outside bar, and 5.5 feet under the same conditions over the inner bar. Some trouble is experienced by large boats in making the turn near the mouth of the creek, the cut being rather narrow at that point.

COMMERCE AND NAVIGATION.

The commerce passing through Jekyl Creek is estimated at about $400,000 per annum. Two steamers regularly use this channel, one making daily trips between Brunswick and Fernandina and the other making semi-weekly trips between Savannah and Fernandina. Vessels are often towed through to avoid rough water at sea, and many small

craft carrying rice or fish pass through the creek. A considerable increase in its commerce would probably result from the improvement of existing shoals.

MISCELLANEOUS.

The work is located in the collection district of Brunswick, Ga. Amount of duties collected in 1889, $8,933.66. St. Simon's is the nearest light-house, and Fort Clinch, Fla., the nearest fort.

The following is the only appropriation ever made for this work:

By act of Congress of August 11, 1888, $5,000.

The total expenditures to June 30, 1889, including all outstanding liabilities, were $4,968.62.

It is proposed to expend any funds which may become available during the year in carrying on the improvement according to the approved project. Should the appropriation be small and irregular the cost will be greatly increased. The sum of $33,950 can be economically and advantageously expended during the present fiscal year.

Money statement.

July 1, 1889, amount available	$233.05
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	201.67
July 1, 1890, balance available	31.38
Amount appropriated by act of September 19, 1890	7,500.00
Amount available for fiscal year ending June 30, 1891	7,531.38
Amount (estimated) required for completion of existing project	26,090.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	26,090.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

O 10.

IMPROVEMENT OF CUMBERLAND SOUND, GEORGIA AND FLORIDA.

The entrance to Cumberland Sound is situated between Cumberland Island, Georgia, and Amelia Island, Florida.

Operations for improving the channel across the bar at this entrance have been carried on in accordance with a project of improvement submitted to the Chief of Engineers by General Gillmore, the officer then in charge, dated June 30, 1879, and printed as Appendix 18, Annual Report of the Chief of Engineers for 1879. A discussion of the general question of the application of jetties to this entrance is published as Appendix H 6, Annual Report of the Chief of Engineers for 1878.

For a detailed history of past work see page 1054, Annual Report of the Chief of Engineers for 1888.

ORIGINAL CONDITION.

The available depth of the entrance in its unimproved condition varied from 11 to 12.5 feet at mean low water. The mean rise and fall of tide is 5.9 feet.

PLAN OF IMPROVEMENT.

The plan of improvement provides for the construction of two low jetties, composed of riprap stone, with a mattress hearting whenever admissible, resting upon a foundation mattress of logs, or logs and brush, starting, respectively, from the shores on opposite sides of the entrance and extending seaward across the bar upon lines so directed that the ends will be parallel to each other, and from 3,000 to 3,500 feet apart, or such distance as may hereafter be deemed necessary. These jetties were intended to establish a low-water channel across the bar not less than from 20 to 21 feet in depth. The cost of improvement was estimated at $2,071,023.

Nothing was ever expended in improving the entrance to Cumberland Sound previous to the adoption of the existing project. Since then six appropriations have been made by Congress for the work, aggregating $480,000. The project of improvement and estimate of cost were based upon insufficient data and need revision. This will be made at an early date, as soon as all of the data therefor has been collected.

North jetty.—The shore end of this jetty is located on Cumberland Island, about 7,700 feet north 26° 30′ west from the eastern bastion of Fort Clinch From this point it extends south 61° 30′ east 2,200 feet, thence south 80° east 5,172 feet to its present seaward end.

Work on this jetty was commenced in June, 1881, and suspended in March, 1883. In addition to the foundation-course, 7,372 feet in length, a second course extends from the angle point shoreward a distance of 1,439 feet. Foundation-courses of two spurs, each 54 feet in length, are also laid on the harbor side of the jetty at distances of 1,627 and 1,800 feet, respectively, from its shore end.

The mattresses of the foundation-course of the jetty vary in width from 25 to 52 feet, and those of the second course from 20 to 25 feet. The spurs are 42 feet wide.

The mattresses are from 19 to 22 inches in thickness, and are loaded with riprap stone to an average depth of 12 inches.

There have been used in the work 46,480 square yards of mattresses and 15,612 cubic yards of riprap stone.

South jetty.—The shore end of this jetty is located on Amelia Island, about 5,800 feet east 18° south from the eastern bastion of Fort Clinch. From this point it extends seaward a distance of 10,062.48 feet, measured along the axis of the work. From the initial point it runs as follows, viz:

	Feet.
Range 1, east	2,041.63
Range 2, north 68° 32′ east	5,625.37
Range 3, north 69° 32′ east	400.00
Range 4, north 71° 32′ east	400.00
Range 5, north 78° 32′ east	400.00
Range 6, north 78° 32′ east	400.00
Range 7, north 80° 2′ east	400.00
Range 8, north 81° east	395.48

In addition to the foundation-course a second course 3,967.9 feet in length extends seaward along the second range, beginning at a point 917.7 feet from the intersection of the first and second ranges.

The mattresses of the foundation-course vary in width, on the first range from 40 to 50 feet, and on the second range from 50 to 100 feet. On all other ranges their width is 100 feet, as is also that of the mattresses of the second course. The mattresses average about 18 inches

in thickness and are loaded with riprap stone to an average depth of 12 inches. This jetty has been brought up to the level of mean low water for a distance of nearly 3,000 feet from its shore end, and with a crest width of 16 feet shoreward of the angle, and of 22 feet seaward of that point. The structure consists of riprap stone upon the mattress foundation. A hearting of oyster shells was tried, but being found to be disadvantageous and not economical was discontinued. The stone has stood well, the slopes assumed on both sides of the jetty being about 1 on $1\frac{1}{4}$. No breaking down of the work at any point has been observed. There have been used in the work 145,197.86 square yards of mattresses, 55,949.85 cubic yards of riprap stone, and 1,253.87 cubic yards of oyster shells. Up to July 1, 1889, the total expenditures on both jetties, including outstanding liabilities, amouted to $413,616.24.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

Operations which were confined to the south jetty were continued under the existing contract with Mr. Anson M. Bangs until November 13, 1889, when work was suspended on account of the exhaustion of the appropriation. There were used in the work 18,060.62 cubic yards of stone and 817.93 cubic yards of oyster shells, bringing up the jetty to mean low-water for a distance of about 1,750 feet from the angle-point, the crest width being 22 feet.

The completion of the survey has been much delayed from the fact that in the field-work some very important velocity and tidal observations were omitted. These have been made as well as was possible under the existing circumstances of continual rough weather and with the limited funds available. It is hoped to be able to complete this work and submit a report thereon within three months.

CONDITION OF WORK JUNE 30, 1890.

An examination of the work was made during the first part of June, 1890. The north jetty remains as noted in former reports. The condition of the south jetty is excellent; no breaking down of the side slopes is apparent, although the last work done has been exposed to much severe weather for a period of seven or eight months. There has been no appreciable movement of the bar seaward, and the depth of water on it remains practically constant at about 13 feet at mean low water. There has been, however, a marked movement of the North Shoals southward, and also, to a less degree, of the South Shoals northward. The shoaling has been considerable, as much as 7.4 feet in one instance. The existing channel between the 12-foot contour along the south side of the North Shoals and the jetty is now but about 350 feet wide, thus showing a contraction in width since the survey of 1889 of about 450 feet.

COMMERCE AND NAVIGATION.

All of the commerce of St. Mary's, Ga., and 90 per cent. of the commerce of Fernandina, Fla., are dependent on water transportation through Cumberland Sound. The trade of Fernandina increases yearly, and in 1889 exceeded that of 1888 by 20 per cent. An estimate based on the first five months of 1890 indicates that the commerce during the

present year will be from 30 to 40 per cent. greater than that of last year.

The Florida Central and Peninsula Railroad, terminating at Fernandina, besides running through a fertile and well-timbered country, pierces also the Florida phosphate fields, and much of the rock from the phosphate mines will be brought by this road to Fernandina for shipment to foreign and coastwise ports. Anticipating this increased traffic the railroad is extending its terminal facilities and building new wharves.

Two steam-ships per week ply between Fernandina and New York, and fifteen steamers per week between Fernandina and local coastwise ports. A large fleet of foreign and coastwise vessels also engage in the commerce of this port.

In 1889 the shipments, foreign and coastwise, amounted to 407,589 tons, valued at $5,000,000, on which the freightage was $1,000,000; and the receipts by water were 43,533 tons, valued at $3,865,000, on which the freightage was $650,000. The number of passengers carried was 4,500.

		Amount.	Value.
Shipments			
Cotton	bales..	34,881	$1,744,000
Naval stores	barrels..	13,090	80,000
Timber	feet..	94,975,000	1,150,000
Fruits and vegetables	crates..	26,450	150,000
Cedar	tons..	50,009	500,000
Miscellaneous	do...	50,000	1,376,000
Total	tons..	407,589	5,000,000
Receipts.			
Railroad iron	do..	13,643	.....
Guano	do..	900	.....
Coal	do..	2,540	.....
Rock	do..	900	.....
Hay	do..	1,550	.....
General merchandise	do..	6,000	.....
Fertilizers	do..	18,000	.....
Total	do..	43,533	3,865,000
Aggregate	do..	451,122	8,865,000

MISCELLANEOUS.

This work is located in two collection districts, the north jetty being in the district of St. Mary's, Ga., and the south jetty in that of Fernandina, Fla. Fernandina, Fla., is the nearest port of entry. Amount of duties collected in 1888, $4,655. Amelia Light is the nearest light-house and Fort Clinch the nearest fort.

Since the existing project for improving Cumberland Sound was adopted the following appropriations have been made for this work:

By act of Congress approved—	
June 14, 1880	$30,000
March 3, 1881	100,000
August 2, 1882	50,000
July 5, 1884	75,000
August 5, 1886	112,500
August 11, 1888	112,550
Total	480,000

The total expenditures to June 30, 1889, including all outstanding liabilities, were $479,550.28.

It is proposed to expend any funds which may become available during the year in accordance with a revised project, which will be submitted as soon as the office work has been completed.

The appropriations heretofore made have been entirely inadequate to an economical and advantageous prosecution of the work of improvement. The most satisfactory results can not be obtained with expenditures during the next fiscal year of less than $1,000,000.

Money statement.

July 1, 1889, amount available	$66,383.76
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	65,934.04
July 1, 1890, balance available	449.72
Amount appropriated by act of September 19, 1890	112,500.00
Amount available for fiscal year ending June 30, 1891	112,949.72
Amount (estimated) required for completion of existing project	1,478,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	1,000,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

REPORT OF MR. MILNOR P. PARET, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., June 30, 1890.

SIR: I have the honor to submit the following report of operations carried on during the fiscal year ending June 30, 1890, for the improvement of Cumberland Sound, Georgia and Florida.

JETTY WORK.

The following table gives the work done during the year. Under an existing contract with Mr. Anson M. Bangs, the prices were for stone, $3.27 per cubic yard, and for shell, $1.27 per cubic yard. All work was done on the south jetty.

Month.	Stone.	Shells.	Advance.
1889.	*Cubic yards.*	*Cubic yards.*	*Feet.*
July	3,981.96	541.27	400
August	4,543.98	276.66	230
September	4,001.31	.....	230
October	4,290.85	.....	20
November	1,242.52	.....	.....
Total in present fiscal year	18,060.62	817.93	880
From last annual report	10,513.00	1,153,87	2,243
Total under the contract	28,573.62	1,971.80	3,123

The work under this contract began at the shore end of the jetty at a point 857 feet from the base line, so that the end of the present work is at a distance of 3,980 feet from the base line. It was all carried up to the elevation of mean low water, the top width at this height being 16 feet from the shore to the angle; and 22 feet from the angle seaward. During the last two months of the work the material was used in making up the jetty to full height and width throughout, thus accounting for the small advance seaward. Work was discontinued and the contract closed on November 13, 1889.

SURVEYS.

The report on the extended survey of Cumberland Sound was rendered in January, 1890; since this time some desired additional information has been obtained, such as samples of the bottom at various localities about the entrance; the final falling velocities in sea water of such samples were obtained, and their loss in weight and bulk, after treatment with nitric acid, such results being given in my report of May 12, 1890.

Additional current observations were taken at three points on the North Shoals. The results are now being worked up in this office. The season of the year in which these observations were taken was quite favorable for accurate results (easterly winds and storms prevailing), it being next to impossible to do work of any nature on the shoals, except after prolonged westerly winds.

On April 15, 1890, a self-registering tide-gauge was established at Fort Clinch; it is the intention to keep this gauge in operation for a sufficiently long period to obtain a thoroughly reliable determination of the plane of mean low water and other tidal data. For the protection of the mechanism of the gauge, a small house was built on three creosoted piles. Two of these piles were driven when the self-registering gauge was put up. The other or third pile was driven there in March, 1889.

A survey of the east shore-line of Cumberland Island for a few miles at its lower end was made with a view of reporting upon the alleged encroachment of the ocean upon the island.

A survey was made in April, 1890, of the shore-line of Amelia Island, along the East River from the United States Military Reservation boundary to the southern limits of the town of Fernandina.

PRESENT CONDITION OF THE WORK.

An inspection of the jetty, made about the 1st of June, 1890, did not show any appreciable breaking down of the side slopes, and scarcely any settlement. For nearly its whole length the stone seems to be compactly cemented together with a growth of oysters and barnacles; on a portion of it, however, this shell growth does not appear. Such a portion is on a stretch a little over 100 feet long, about 350 feet west or shoreward from the angle. The stone used here was a Connecticut granite and was ballast obtained from a vessel then in port. An examination was made of the bar during the first week in June, 1890; the changes here are quite marked. I submit a tracing giving the soundings taken and the relative positions of the 12 and 18 foot contours of 1889 and the same contours of June, 1890. At a point about 1,600 feet eastward from Station E or "The Boilers," the 12-foot contour has moved south a distance of nearly 500 feet, and for a length of about 1,400 feet. East and west of this the present contour approaches that of 1889. The shoaling in this area has been as great as 7.4 feet. At the onter end of the south jetty, the 12-foot contour has moved north a distance of about 450 feet for a length of nearly 800 feet, the shoaling averaging about 2½ feet. About 1,200 feet east from the end of the jetty the same contour has moved north about 300 feet, the average shoaling being about 2 feet.

The 18-foot contour has moved west and south about 400 feet. The deep water now crosses the jetty at a point about 2,000 feet west from the outer end, the tendency seeming to be to form a channel across the South Breakers just south of the jetty. The width of channel between the jetty and the 12-foot contour is now about 350 feet, whereas in the early part of 1889 the width of channel was quite 800 feet. The positions of all the buoys have lately been changed to correspond with the existing channel. At the shore end of the jetty the high-water line has moved seaward about 250 feet, and the low-water line about 300 feet.

Very respectfully, your obedient servant,

MILNOR P. PARET,
Assistant Engineer.

Lieut. O. M. CARTER,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

Arrivals and clearances of vessels, and commerce, at Fernandina, Florida, from January 1, 1875, *to December* 31, 1889.

ARRIVED.

Year.	Coastwise.			Foreign ports.						Total.		
				American vessels.			Foreign vessels.					
	No.	Tons.	Crew.	No.	Tons.	Crew.	No.	Tons.	Crew.	No.	Tons.	Crew.
1875..	212	117, 363	4, 192	47	10, 379	359	12	7, 437	135	271	135, 179	4, 686
1876..	210	141, 354	4, 749	25	4, 893	179	28	9, 232	249	263	155, 479	5, 177
1877..	150	100, 581	3, 343	31	3, 768	217	40	12, 547	404	221	121, 896	3, 964
1878..	183	120, 845	3, 900	17	3, 985	101	22	8, 294	215	222	133, 124	4, 216
1879..	205	133, 020	4, 133	28	10, 634	252	10	5, 639	126	243	149, 293	4, 516
1880.	270	146, 722	4, 470	34	22, 396	598	22	9, 463	240	326	188, 581	5, 308
1881..	273	171, 548	4, 186	17	11, 899	314	24	11, 593	271	278	195, 040	4, 771
1882..	239	146, 383	3, 279	16	9, 056	242	15	6, 639	151	270	162, 078	3, 672
1883..	183	96, 937	2, 453	6	1, 769	43	14	5, 229	137	203	103, 935	2, 633
1884..	176	105, 061	2, 864	3	865	21	10	4, 029	88	189	109, 755	2, 973
1885..	169	111, 698	3, 131	7	999	47	22	9, 785	210	198	122, 482	3, 388
1886..	205	147, 418	4, 014	7	2, 112	53	15	5, 187	146	227	154, 717	4, 213
1887..	349	317, 798	5, 030	19	6, 402	122	22	8, 565	220	390	332, 965	5, 372
1888..	274	179, 130	4, 456	19	7, 152	156	18	6, 789	177	311	193, 071	4, 789
1889..	262	164, 229	3, 908	48	16, 434	369	39	12, 936	363	349	193, 594	4, 640

CLEARED.

1875..	229	121, 028	4, 303	31	8, 239	228	15	5, 343	212	275	134, 610	4, 743
1876..	244	161, 154	5, 058	21	6, 040	147	26	9, 002	269	291	166, 196	5, 474
1877..	165	106, 615	3, 590	24	6, 340	166	42	13, 741	412	231	126, 596	4, 168
1878..	195	124, 883	4, 086	19	4, 911	123	26	9, 080	236	240	138, 874	4, 445
1879..	175	129, 654	4, 079	31	11, 067	258	12	8, 016	164	218	148, 737	4, 501
1880..	244	155, 659	4, 505	31	14, 207	327	24	10, 202	240	299	180, 068	5, 072
1881..	204	138, 593	3, 730	41	22, 007	506	31	15, 335	351	276	175, 940	4, 587
1882..	217	136, 666	3, 166	39	15, 497	370	31	14, 962	321	287	167, 125	3, 857
1883..	153	85, 815	2, 245	32	8, 925	210	24	9, 413	231	209	94, 153	2, 681
1884..	178	104, 462	2, 688	27	8, 831	176	15	6, 488	158	210	119, 781	3, 022
1885..	185	112, 936	2, 970	33	10, 251	249	21	9, 393	221	239	132, 580	3, 440
1886..	214	153, 092	4, 208	27	9, 072	200	26	9, 817	299	267	171, 981	4, 707
1887..	306	326, 342	4, 500	29	8, 552	232	33	11, 607	327	368	346, 501	5, 059
1888..	280	175, 490	4, 586	28	9, 190	184	20	8, 622	204	328	193, 302	4, 974
1889..	298	181, 075	4, 240	46	13, 652	342	45	16, 286	428	389	211, 013	5, 010

COMMERCE.

Year.	Value of exports.		Value of imports.		Total commerce.	Duties collected.
	Foreign.	Coastwise.	Foreign.	Coastwise.		
1875	$209, 791	$1, 119, 979	$14, 304	$755, 718	$2, 089, 792	$1, 817. 84
1876	226, 076	1, 170, 240	46, 179	1, 131, 032	2, 573, 827	2, 181. 40
1877	310, 225	676, 855	19, 304	1, 146, 363	2, 152, 747	2, 376. 00
1878	248, 000	780, 607	8, 142	172, 234	1, 901, 983	2, 090. 00
1879	275, 470	921, 368	11, 038	1, 360, 432	2, 568, 308	3, 424. 00
1880	257, 780	667, 092	3, 676	1, 365, 857	2, 294, 405	7, 808. 00
1881	242, 100	1, 064, 394	11, 791	1, 786, 546	3, 104, 831	8, 183. 00
1882	292, 400	1, 342, 421	45, 792	7, 536, 588	3, 217, 201	36, 590. 00
1883	248, 600	2, 573, 010	11, 229	2, 262, 755	5, 095, 594	5, 566. 00
1884	173, 600	1, 164, 462	1, 874	1, 738, 620	3, 078, 556	1, 331. 00
1885	214, 726	2, 134, 541	4, 180	1, 502, 544	3, 855, 991	1, 451. 28
1886	191, 595	2, 843, 000	590	1, 625, 000	4, 660, 185	808. 00
1887	226, 960	3, 500, 000	23, 896	2, 000, 000	5, 750, 856	3, 400. 00
1888	175, 150	2, 500, 000	.....	650, 000	3, 325, 150	4, 655. 06
1889	325, 980	3, 970, 180	601	3, 150, 000	7, 446, 761	4, 712. 40

W. A. MAHONEY,
Collector.

First Lieut. O. M. CARTER,
Corps of Engineers, U. S. A.

Arrivals and clearances of vessels, and commerce, at St. Mary's, Georgia, from January 1, 1879, *to December* 31, 1889.

ARRIVED.

Year.	Coastwise.			Foreign ports.						Total.		
				American vessels.			Foreign vessels.					
	No.	Tons.	Crew.	No.	Tons.	Crew.	No.	Tons.	Crew.	No.	Tons.	Crew.
1879	53	16,773	378	6	2,303	54	14	5,155	143	73	24,231	475
1880	30	8,982	202	2	694	17	16	6,409	185	48	16,085	404
1881	22	7,541	156	6	2,491	54	25	11,:82	290	53	21,324	500
1882	28	10,504	196	1	371	7	15	5,723	146	44	16,598	347
1883	26	9,596	132	3	1,207	24	.6	2,112	44	35	12,912	250
1884	32	11,294	224	1	539	9	6	2,334	57	39	14,065	290
1885	40	13,042	280	1	396	8	5	2,028	52	46	15,466	340
1886	20	7,882	140	1	321	7	6	2,(86	56	27	10,288	203
1887	37	13,247	222	1	405	9	8	4,286	90	46	17,938	321
1888	55	20,897	440	1	433	8	3	1,365	32	39	22,695	489
1889	60	24,000	540	9	3,575	70	14	5,571	133	83	33,146	743

CLEARED.

1879	53	16,773	378	10	3,577	83	14	5,155	143	77	25,505	604
1880	30	8,982	202	3	1,150	27	12	4,979	132	45	15,111	361
1881	22	7,541	156	7	3,362	68	29	12,463	323	58	23,336	547
1882	28	10,504	196	4	1,567	32	18	6,791	175	50	18,862	403
1883	26	9,596	182	3	1,207	24	6	2,112	46	35	12,915	252
1884	32	11,294	224	2	1,097	19	6	2,234	57	40	14,625	300
1885	40	13,042	280	3	1,195	25	4	1,595	42	47	15,732	347
1886	20	7,882	140	5	2,312	40	5	1,646	45	30	11,840	210
1887	....	.....	.....	1	425	9	8	4,286	90	8	4,286	90
1888	56	21,330	448	5	2,086	41	5	1,857	46	66	25,273	535
1889	60	24,000	540	9	3,575	70	14	5,571	133	83	33,146	743

COMMERCE.

Year.	Value of exports.	Year.	Value of exports.
1879	$82,491	1885	$27,127
1880	70,411	1886	36,520
1881	149,333	1887	428,500
1882	47,216	1888	212,045
1883	26,902	1889	343,496
1884	22,517		

E. A. McWHORTER,
Collector.

O 11.

PRELIMINARY EXAMINATION OF OCONEE RIVER, GEORGIA.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., December 22, 1888.

GENERAL: I have the honor to submit the following report of a preliminary examination of the "Oconee River, Georgia," in accordance with instructions contained in Department letter, dated August 28, 1888.

The Oconee River rises in the northeastern part of Georgia, flows in a southeasterly direction, and unites with the Ocmulgee to form the Altamaha. In the upper portion of the stream the slope is very great and the channel is obstructed by ledges of rock and bars of sand and gravel. In the lower portion of the stream the slope is more gentle and the principal obstructions are snags, overhanging trees, and sand-bars. The river flows through the wire-grass and long-leafed pine belt of the State of Georgia Lumber and naval store interests are increasing in importance each year and good farm lands are abundant and cheap. The country drained by the Oconee River has comparatively few railroads and is dependent very largely on the river for the transportation of its products to market.

Between 1815 and 1842 about $45,000 were expended by the State in the improvement of this river, and between 1874 and 1885 about $8,575 were expended by the Oconee Steam-boat Company between Dublin and the Central Railroad Bridge, a distance of 28 miles.

In obedience to the instructions of Congress an examination of the Oconee River from Milledgeville to the mouth was made under the direction of General Q. A. Gilmore, of the Corps of Engineers, in 1874, and the cost of securing a low-water channel 3 feet deep was estimated at $10,500. The river was recommended as not worthy of improvement. In 1878 the first appropriation for this work was made by Congress, and the original estimate of cost of securing a 3-foot low-water channel was increased to $15,000. This was found to be totally inadequate, and in 1880 the amount was increased to $50,000, and in 1888 to $100,000.

The appropriations made by Congress for this river up to the present date aggregate $45,000, and more than $31,000 have been expended, $1,500 of which were applied to that part of the river between Skull Shoals and the Georgia Railroad Bridge.

As a result of the work done boats were enabled, when operations were suspended in 1885, to run at a stage of water 4 feet lower than before the improvements were begun, although irregular and insufficient appropriations have made it impossible to secure the most suitable working plant or to use economically that on hand.

The river and harbor act of August 5, 1886, appropriated $1,500 to be expended between Skull Shoals and the Georgia Railroad Bridge. This was expended and the work was completed in 1887, the depth of water aimed at, 20 inches at extreme low water, having been secured. This reach of 17½ miles from Skull Shoals to the Georgia Railroad Bridge is an isolated section of the river, the bridge, which is at the lower end of the reach in question, being 54 miles above Milledgeville, the proposed head of navigation. Between the bridge and Milledgeville the slope of the river is very great and the channel is obstructed by shoals the improvement of which would be very expensive, and not justified by the present or prospective commerce. The reach between Skull Shoals and the Georgia Railroad Bridge was improved principally to cheapen transportation from a cotton mill at Skull Shoals to the railway. The

local traffic alone could not support a steam-boat, and until the mill is again operated there is no necessity of any further expenditure of money at that locality, the present depth of water being sufficient to accommodate any boat likely to be built there.

From Milledgeville to the Central Railroad Bridge, a distance of 45 miles, but little is known of the condition of the river, the bridge being so low as to bar the passage of steam-boats. In 1874, however, it was reported that the usual low-water depth in this reach exceeded 4 feet, with occasional short shoals having only 2 feet to 2½ feet at extreme low water.

The appropriations for the improvement of the Oconee River have been applied principally between the Central Railroad bridge and Dublin, a distance of 28 miles, the object being to provide an outlet for the commerce of Dublin, the county seat of Laurens County, which was then dependent upon a 26 mile haul by wagons over poor roads. At present the Western Tennessee and Dublin Railway, recently constructed, offers better transportation facilities, and as there is not enough commerce on this reach of 28 miles to induce a boat to run (the railroad bridge between preventing it reaching Milledgeville), the principal steam-boat traffic is now between Dublin and the mouth of the river, a distance of 110 miles.

The rapidly-increasing importance of the lumber, naval stores, and farming interests in this section call for an early improvement of the river in order that the products may be gotten to market.

In 1880 the counties bordering the river within the limits of the proposed improvement had an assessed valuation of $7,475,214.

Commercial statistics have been very difficult to obtain, the people living near and doing business upon the river being either unable or unwilling to accede to the repeated requests sent to them for such information. Such data as I give were compiled by Mr. F. C. Armstrong, assistant engineer, who has been for some time in local charge of the river.

Commercial statistics.

Years.	Guano.	Spirits turpentine.	Rosin.	Cotton.	Merchandise.	Lumber and timber.	Miscellaneous products.
	Tons.	*Barrels.*	*Barrels.*	*Bales.*	*Tons.*	*Feet.*	*Tons.*
1880–81	3,000	.....	.....	.....	.....	.....	.....
1882–83	850	.....	.....	3,000	.....	.....	7,014
1884–85	.....	4,400	17,000	.....	.....	.....	6,000
1887–88	1,348	11,434	49,293	1,573	1,660	30,000,000	.....

There are now two steam-boats plying in the river, but these are much interfered with by snags, overhanging trees, and other obstructions.

From all of the foregoing I am of the opinion that the Oconee River is worthy of improvement, but whether Dublin or Milledgeville should be taken as the head of navigation can only be determined by a detailed survey, which should extend from Milledgeville to the mouth of the river. The sum needed for this survey is $1,000.

I respectfully recommend that this sum may be allotted and the survey ordered.

Very respectfully, your obedient servant,

O. M. CARTER,
First Lieut., Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

SURVEY OF OCONEE RIVER, GEORGIA.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., February 5, 1890.

GENERAL: In accordance with the requirements of section 13 of the river and harbor act of August 11, 1888, and instructions from the Chief of Engineers, dated June 21, 1889, I have the honor to submit herewith my report upon the survey of the Oconee River, Georgia, together with a project for its improvement and an estimate of the cost of the same.

A description of this river and such information as I was able to collect concerning its commercial importance are given in my report of the preliminary examination, dated December 22, 1888, to which I respectfully refer.

The survey of the river from Milledgeville to the mouth was made under my direction during October, 1889, by Mr. A. S. Cooper, assistant engineer, whose very complete report is appended hereto.

The basin of the Oconee River above Milledgeville comprises an area of 2,790 square miles. The river valley in this section is narrow, and is bordered by hilly country comprising some of the best farming lands in the State of Georgia. The slope of the river above Milledgeville is very great, and the channel is much obstructed by shoals, the improvement of which, so as to admit of steam-boat navigation, would require an expensive system of locks and dams not justified by the present or prospective commerce. The area of the river basin below Milledgeville is 2,610 square miles. The river valley in this section is wider than that above Milledgeville, and is covered by forests of oak, maple, sycamore, gum, cypress, cottonwood, and willow. The adjacent country is not only excellent farming land, but contains immense quantities of yellow pine which reaches a market by being rafted down the river to the coast. The distance from Milledgeville to the mouth of the river, measured along the channel, is 149.3 miles, and the low-water fall is 158.5 feet, an average of 12.72 inches per mile. The slope is nearly uniform from Milledgeville to the river's mouth. Steeper slopes, over distances of from one-half to three-quarters of a mile, occur as follows:

Locality.	Distance above forks.	Fall in feet per mile.	Depth summer low water.	Character of bottom.	Remarks.
	Miles.		*Feet.*		
Raft	120.3	2.5	(*)	Unknown ..	Choked with trees and snags.
———	113.2	2.0	8.0	Sand	
Tom's Point	103.2	2.0	3.5	...do	Cut-off.
Shoal No. 24	99.0	2.0	4.0	Rock	
Parson's Shoal	96.3	2.5	4.0	...do	
Carr's Shoal	84.0	3.2	4.0	...do	
Fish Trap	72.5	2.0	3.0	Sand	Do.
Flat Creek	62.7	3.0	5.0	...do	
———	27.2	3.0	5.0	...do	
Gordon's Cut	19.1	2.0	4.0	...do	

* Unknown.

The Oconee River has no tributaries of importance. It is subject to extreme fluctuations in water-level, the freshet of August, 1887, reaching at Milledgeville a height of 38 feet above summer low water. Freshets of such magnitude as the one just mentioned are of rare occurrence, but during the winter season of nearly every year the river rises

out of its banks and floods the bottom lands to a depth of from 3 to 10 feet.

The discharge of the river at Milledgeville varies from about 1,200 cubic feet per second at extreme low water to perhaps 75,000 cubic feet per second during high freshets. During the freshet of 1887 it is probable that the discharge at that point exceeded for a time 100,000 cubic feet per second, but no accurate or satisfactory determination of this could be made.

The discharge at Dublin was found to be 1,990.5 cubic feet per second with a mean velocity of 1.34 feet per second; at Bell's Ferry, to be 2181.9 cubic feet per second, with a mean velocity of 1.09 feet per second. These determinations were made with the water at about the ordinary low stages of summer.

The ordinary low-water discharge of the Oconee River is sufficient, if properly directed and confined, to afford a navigable channel 3 feet deep at summer low water between Milledgeville and the river's mouth. This depth is sufficient for the present and prospective commercial demands.

During high water the navigation of the Oconee River below Ball's Ferry, the only portion where boats now run regularly, is embarrassed only by overhanging trees. Above that point navigation is closed by the Central Railroad Bridge and by a raft of logs, 29 miles below Milledgeville.

During ordinary summer low water, with the exception of particular localities hereafter described, the river current is moderate, the depths exceed 4 feet, and the widths are ample. The channel is, however, greatly obstructed by numerous snags, logs, and overhanging trees, and below the railroad bridge by sand-bars and ledges of rock or gravel as well.

Some of the sand bars result from cut-offs. The river channel through the bottom lands is very tortuous, the stream returning at times after a détour of a mile or more to within 50 or 100 feet of the previous bight. The neck of land separating the two portions of the river gradually becomes narrower by the erosion of the banks on either side, and in time the old channel is abandoned and a cut is formed through which, owing to the increased slope, the current is very rapid. In the course of time the slope adjusts itself to the general slope of the river for that vicinity, but on this river nearly all of the cuts that have thus been formed in recent years offer greater difficulties to navigation than did the original channel. Such cuts have also resulted, at some places, in developing new shoals in the reaches above. Unless special conditions in any particular case render the formation of a cut advantageous, it is preferable to prevent, by protecting the banks and otherwise, rather than to aid artificially or to allow natural agencies to cause its formation.

The survey of the river was made when the water was but little above the low stage of summer, and the general maps show the character and extent of the obstructions encountered.

Detailed examinations were not made at all of the places where navigation is obstructed, and in making estimates of the cost of improvement the information obtained during the survey has been supplemented by that obtained from personal examinations as well as from other reliable sources.

The principal obstructions encountered in ascending the river are given in Mr. Cooper's report. Those places where works of improvement are now recommended are given in the following table:

No. of obstruction.	Distance above forks.	Name.	Character.	Recommendations.	Estimated cost of improvement.
	Miles.				
1	0.9	Old boat yard.....	Sand-bar.....	To build spur-dikes of piles and brush for the contraction and regulation of the low-water channel.	$7,500
2	2.6 and 2.8	Bryant's Floating Mill.	Rockledge and sand-bar.	To remove a small quantity of rock, and to construct contracting works of rock and of piles and brush.	2,500
3	3.6	Shoal No. 1	Rock ledge....	A small amount of excavation needed	750
4	5.5	Shoal No. 2	....do.....	.....do.....	1,000
5	5.8	Quinn's Shoal.....	... do	.....do.....	2,500
6	6.6	Cheney's Shoal ...	....do	Channel through ledge should be widened.	1,500
7	6.9	Shoal No. 3	....do	A small amount of rock should be removed from channel.	450
8	7.1	Shoal No. 4	....do	Some rock excavation needed.....	1,000
9	7.6	Shoal No. 5 and Cut-off No. 1.	Sand-bar and cut-off.	Logs should be removed to enable boats to reach deep water, and possibly low-water channel should be contracted; cut-off should be closed.	1,750
10	8.0	Cut-off No. 2.....	Cut-off.....	Should be closed.....	1,000
11	9.6	Cut-off No. 3.....	....do	.....do.....	300
12	10.1	Cut-off No. 4.....	....do	.....do.....	300
13	10.4	Shoal No. 6	Sand-bar.....	To construct spur-dikes for contraction and regulation of low-water channel.	1,500
14	10.5	Cut-off No. 5.....	Cut-off.....	Should be closed	600
15	11.2	Cut-off No. 6.....	....do	.....do.....	400
16	12.5	Shoal No. 7	Sand-bar.....	To construct spur-dikes for contraction and regulation of low-water channel.	2,500
17	13.6	Browning's Landing.	....do	.....do.....	1,500
18	18.7	Ocmulgee Cut....	Projecting points and Old River.	Points should be eased off to render channel easy for steam-boats, and Old River should be obstructed.	750
19	19.3	Cut-off No. 7	Cut-off.....	Should be closed	300
20	19.4	Cut-off No. 8.....	....do	.....do.....	100
21	20.8	Old River	Old River.....	Should be obstructed	250
22	23.0	Cut-off No. 9	Cut off.....	Should be closed	500
23	23.7	Salt-House Shoal.	Rock ledge ...	A small amount of excavation needed....	500
24	24.9	Shoal No. 8.....	Sand-bar.....	To construct spur-dikes for the contraction and regulation of the low-water channel.	1,500
25	27.5	Old River.....	Old River.....	To partially obstruct entrance to old river .	250
26	30.3	Shoal No. 9	Rock ledge ...	A small amount of excavation needed....	750
27	35.6	Walton's Bar.....	Sand-bar	To construct spur-dikes for the contraction and regulation of the low-water channel.	1,500
28	37.0 to 38.1	Center Cut	Sand-bars.....	Points should be trimmed and Old River closed to throw more water through the cut.	2,000
29	41.0	Red Bluff.....	Sand-bar.....	To construct spur-dikes for the contraction and regulation of the low-water channel.	2,500
30	43.0	Jack Williams's Suck.	Cut-off.....	Should be closed	500
31	44.2	Odam's Ferry Bar.	Sand-bar	To construct spur-dikes for the contraction and regulation of the low-water water channel.	1,500
32	47.5	Cut-off No. 10	Cut-off	Should be closed.....	150
33	48.2	Rifle Cut.....	....do	To partially obstruct Old River	250
34	49.2	Cut-off No. 11.....	....do	.....do.....	100
35	51.9	Cut-off No. 12.....	....do	.....do.....	150
36	52.8	Shoal No. 10	Sand-bar.....	To construct spur-dikes for the contraction of the low-water channel and to close cut-off.	1,750
37	58.4	Stave Landing....	....do	To construct spur-dikes for the contraction of the low-water channel.	1,500
38	63.0	Flat Creek Bar ...	....do	.....do.....	1,500
39	67.7	Poor Robin Bar..	....do	.....do.....	2,500
40	72.4	Fish Trap Bar....	Sand-bar and rock ledge.	To remove loose rock, and construct spur-dikes for the contraction of the low-channel.	2,000
41	72.9	Fish Trap Cut....	.....	To partially obstruct Old River	450
42	73.0	Shoal No. 11	Sand-bar.....	To construct spur-dikes for the contraction and regulation of the low-water channel.	1,750
43	74.1	Little Buzzard Bar	....do	.....do.....	750
44	77.9	Shoal No. 12	Rock ledge ...	The channel should be deepened and loose rock removed.	750
45	79.2	Shoal No. 13	Bowlders	To remove isolated rock bowlders.....	500
46	79.5	Shoal No. 14	Rock ledge ...	A small amount of excavation needed to improve channel.	500

No. of obstruction.	Distance above forks.	Name.	Character.	Recommendations.	Estimated cost of improvement.
47	80.7	Shoal No. 15	Rock ledge	A cut should be made through ledge	$750
48	80.8	Shoal No. 16	do	Projecting points of ledge should be removed	500
49	81.1	Big Creek Shoal	do	That portion of ledge projecting into channel should be removed.	2,500
50	81.8	Shoal No. 17	do	To remove rock interfering with low-water navigation.	1,000
51	82.1	Shoal No. 18	do	To widen channel and remove rock interfering with low-water navigation.	500
52	83.2	Dominie's Shoal	do	do	1,500
53	83.8	Shoal No. 19	Sand-bar	To construct spur-dikes to contract and regulate the low-water channel.	1,500
54	84.0	Carr's Shoal	Loose rock	To remove loose rock interfering with navigation.	250
55	84.6	Shoal No. 20	do	do	750
56	85.6	Shoal No. 21	Rock ledge	A small amount of excavation needed	750
57	88.2	Guyton's Bluff	do	To remove part of ledge projecting into channel.	500
58	90.2	Shoal No. 22	Sand-bar	To construct spur-dikes for the contraction of the low-water channel.	2,000
59	93.1	Shoal No. 23	Rock ledges	To remove portion of ledges interfering with navigation.	750
60	96.3	Parson's Shoal	Rock ledge	To widen channel and remove portion of ledge interfering with navigation.	1,000
61	99.0	Shoal No. 24	Bowlders	To remove bowlders interfering with navigation.	500
62	99.4	Cut-off No. 13	Cut-off	Should be closed	200
63	99.9	Shoal No. 25	Rock ledge	To remove portion of ledge projecting into channel.	500
64	103.1	Tom's Point	Sand-bar	To close Old River	1,000
65	117.2	Cut-off No. 14	Cut-off	Should be closed	100
66	117.9	Cut-off No. 15	do	do	750
67	119.4	Cut-off No. 16	do	do	450
68	120.3 to 120.8	Raft	Logs, stumps, etc.	Sweeney's Cut should be opened, and Old River further obstructed.	9,000
69	146.5	Fishing Creek		It is probable that one of the channels around Fishing Island must be closed. Further examination is needed before determining upon the plan of improvement. It will probably not cost more than $2,000.	2,000
					83,300
For improvement of shoals possibly developed by changes in the regimen of the river due to alterations of the river slope, and for bank protection in various places					15,000
Removal of 10,000 overhanging trees, at 50 cents each					5,000
Removal of 10,000 snags and logs, at $3 each					30,000
Working plant					15,000
Total					148,300
Engineering and contingencies, 15 per cent.					22,245
Aggregate					170,545

The above estimates are based upon the assumption that at least $50,000 will be annually available for the work. Should the appropriations be small in amount or irregularly made, the cost of improvement will be greatly increased.

Rock shoals once properly removed will not re-appear. With this exception no permanent improvement of the Oconee River can ever be effected at any reasonable cost. The soil composing the bed and banks of the river is so easily eroded that new obstructions caused by logs, snags, and overhanging trees form during every high-water season, and as the regimen of the river changes new shoals of rock, gravel, or sand are developed, and the position and extent of sand-bars now in existence, but not at present needing improvement, will be modified. To what extent this change will take place can not be foreseen, and no accurate estimate for the improvement and maintenance of the river can now be made. The estimate submitted herewith is for the removal of

the existing obstructions to navigation. When new obstructions form estimates for their removal can then be made. The river, once cleared of the most troublesome and dangerous logs and snags, will require a snag boat for perhaps only two or three months of each year, making the probable cost of maintenance of the completed work from $3,000 to $5,000 annually.

The value of the present annual commerce upon this river is about $1,000,000.

The population of the counties bordering upon the Oconee River at and below Milledgeville is estimated at 90,000, and the total value of personal and real property at about $11,000,000.

The value of the farm products in this region for the year 1889 amounted to about $4,000,000.

The area of the section of country naturally tributary to the Oconee River is about 1,900 square miles. The railroads of this region all cross the river valley nearly at right angles to its length and do not offer suitable facilities for collecting the produce or supplying the needs of the river districts lying between them. Were the Oconee River placed in good navigable condition from Milledgeville to its mouth it is probable that the present river commerce would be increased at least threefold.

It would render accessible a large supply of various kinds of timber; would further stimulate the rapidly growing agricultural interests and effect a reduction of freight rates over the tributary river basin.

In view of the facts collected, the Oconee River is considered worthy of improvement from Milledgeville to its mouth, with a view to obtaining a navigable channel 3 feet in depth at ordinary summer low water.

The cost of the improvement is estimated, in round numbers, at $171,000.

The sum of $50,000 can be advantageously and economically expended during the present fiscal year.

The following papers and maps accompany this report:

1. Report of Mr. A. S. Cooper, assistant engineer.
*2. Index map of Oconee River from Milledgeville to the mouth.
*3. General map of the Oconee River from Milledgeville to the mouth (in nine sheets).
*4. Profile of the Oconee River from Milledgeville to the mouth.
†5. Maps of detailed surveys of the Oconee River (in two sheets).

Respectfully submitted.

O. M. CARTER,
First Lieut., Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. A. S. COOPER, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., January 31, 1890.

SIR: In accordance with the following letter of instructions, and also verbal orders given about the same time, I proceeded to Milledgeville, Ga., and organized a party for the purpose of making a survey of the Oconee River.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., August 13, 1889.

SIR: After the survey of the Ocmulgee River is begun you will proceed to Milledgeville, Ga., and make a survey of the Oconee River from Milledgeville to the river's mouth.

You will note the height, character, and condition of the river banks, the size and variety of trees and brush, the length and depth of pools and shoals, the variations in water level at different points, the nature of the river bottom, and the location,

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*Omitted; printed in House Ex. Doc. No. 211, Fifty-first Congress, first session.
†Omitted.

nature, and magnitude of existing obstructions to navigation, with a view to determining the methods and probable cost of removing them so as to secure a depth of three feet at summer low water.

You will also collect statistics, as much in detail as possible, concerning the character and amount of commerce and navigation, prospective as well as at present, interested in th · proposed improvement.

The high and low water slopes of the river will be determined instrumentally, permanent bench-marks being established at intervals along the line. Near Milledgeville, Dublin, and the mouth of the river, cross-sections of the river will be carefully determined for use in discharge measurements. Where practicable these sections will be continued to the high-water mark by leveling and permanent bench-marks established. The velocity measurements will be made by means of loaded rods, surface or double floats, and the low, ordinary, and high water discharges obtained. Permanent gauge staves will be established at Milledgeville, Dublin, and near the mouth of the river, and intelligent gauge readers employed at a compensation not to exceed $7.50 per month. The gauges will be connected with at least two good prominent and permanent bench-marks. Detailed descriptions, with sketches, will b · given of all bridges crossing the river. The map of the survey, which will be plotted on a scale of $\frac{1}{9600}$, should show the general contour of the river banks, the location of the navigable channel, with low-water depths, the location of cut-offs, sand bars, etc. At shoals where rock excavation or works of contraction may be required, detailed surveys on a scale of $\frac{1}{1200}$ will be made, and the river slope from the pool above to the pool below carefully determined. The profile of the river will be plotted on a horizontal scale of about 2 miles to an inch, and a vertical scale of about 30 feet to an inch.

In view of the verbal orders given to you no further written instructions are considered necessary.

You are authorized to employ such assistance and means of transportation as may be required for a vigorous prosecution of the work. * * *

Your field maps will be kept plotted to date, and the usual tri-monthly reports of operations submitted to this office. As soon as the field work of the survey is completed, all employés will be discharged and you will return to this office.

Very respectfully, your obedient servant.

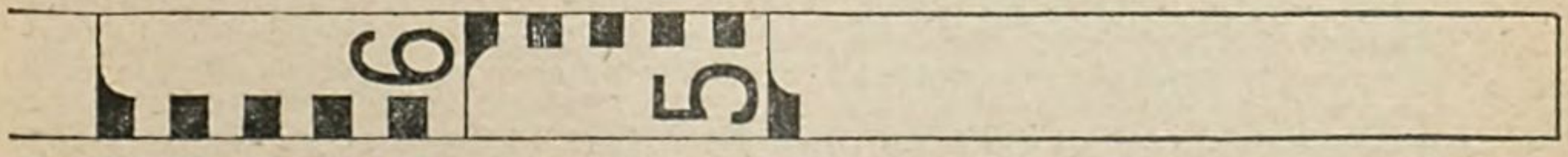
O. M. CARTER,
First Lieut. Corps of Engineers.

Mr. A. S. COOPER,
Assistant Engineer, Savannah, Ga.

Hearing of an obstruction that existed about 10 miles above the Central Railroad Bridge that would not admit of the passage of boats, I made arrangements to do the work to the bridge by using small boats and a light camping outfit. Arrangements were also made to build a flat with a house suitable to accommodate my entire party, near Station Oconee (Central Railroad crossing of the river), to be ready for use upon my arrival at that point.

On September 25, 1889, I left Milledgeville with my party, consisting of one rodman, three boatmen, and one leadsman, using two small row-boats for the survey, and one somewhat larger than either of the other two for the baggage. The work was begun at the Georgia Railroad Bridge, about 2 miles above Milledgeville, in order to connect my levels with the railroad levels. The Central Railroad Bridge was reached October 2, 1889. The flat which had been built here for my use was found sunk and nearly turned over by the last high water. After righting, raising, and cleaning it the survey was again resumed on the 5th of October. A cook, and a deck-hand to manage the flat, were here added to the party. The field-work of the survey was completed October 22.

The work was done with a Blunt transit, having about a 5-inch limb, with a level attachment under the telescope. Distances were taken with a stadia rod, and courses with the needle only, thus avoiding the necessity of taking back sights. The stadia rod used was graduated to feet and tenths instead of being marked to record distances direct, thus enabling me to use it as a self-reading rod for the level work. The rod was made of white pine, 4 inches wide, 16 feet long, 1 inch thick at the center and dressed down to three-eighths at both ends. It was marked in the following manner:



The figures were made 6 inches high in order to use them when the rod was so far off that the black and white squares could not be read. Distances above 10 feet were marked with only the last figure, placing a red 0 for the 10, to call attention to the point where this change took place.

The method used in doing this work was as follows: The instrument having been set up and leveled, the rod was sighted while at the water's edge at a point up-stream, and the course, distance, and height of the water at that point recorded. The rod man then went ahead of the transit, as near as possible the same distance that he was behind before moving. While going ahead and when about opposite the transit he held up the rod so as to give the width of the river at that point. If the river was open a point on shore was chosen and a stake driven at the water's edge and on a level with it. The course by the needle and the distance with the stadia rod to this new point were then taken, height of water also being noted. The transit was then moved ahead of the rod. If the bank was covered with trees, the boatman would hold the boat still while the rodman gave a sight on a solid snag or on the water's surface. If, however, the river was not at a stand or nearly so, he was not allowed to use the latter method of turning.

While going ahead with the transit, soundings were taken and noted down on a sketch of the river made while moving from point to point of the survey. All obstructions, heights of bank, character of same, nature of the country, timber, brush, and in fact everything that would be needed in making a complete map of the river was noted down on this sketch as the work progressed. The distance from station to station was determined by reference to a table of values of the stadia wires, which was computed before the survey began from a series of observations taken with this same rod when placed at known distances (from 100 to 2,000 feet) from the transit. The elevations were taken with this same rod, estimating to hundredths of a foot, and a book or small board was used as a target when unusually long sights were necessary. In all cases it was the intention to take sights about 1,500 feet long, but in many instances as long as 3,000 foot sights became necessary in order to avoid great delays in cutting brush and trees. Each morning the instrument was adjusted and closely watched all day. In one instance an adjustment became necessary three times in one day. To all elevations taken at distances of more than 600 feet, a correction for curvature and refraction was applied in accordance with the following table:

Distances in feet.	Corrections to be subtracted.	Distances in feet.	Corrections to be subtracted.
	Feet.		*Feet.*
600	.01	2,400	.12
900	.02	2,700	.15
1,200	.03	3,000	.19
1,500	.05	3,600	.27
1,800	.07	4,500	.42
2,100	.09		

All sights being over water these corrections were applied with good results. All places that were especially bad were surveyed much more in detail than the regular line survey. This was done by setting the instrument in a position that would command the entire portion of the river to be surveyed and the zero degree of the plate turned to magnetic north and kept in that position while the detailed survey was being made. An extra man was then put into the boat used for soundings to hold up the stadia rod which was always held facing toward the transit. The boat was then rowed to where soundings were needed, and angles and stadia distances taken to it as rapidly as possible. On completion of this work a sight ahead was taken in the usual manner and the main survey continued until another bad place was reached. Places, however, that were only slightly worse than the general average of the river were sketched more carefully and on a larger scale than the regular sketch, and soundings taken all over the place and placed on these sketches by estimating their proper location. Soundings were taken with a pole graduated to feet and tenths where the water was 15 feet or less in depth; in all other places soundings were taken with a lead line.

At Milledgeville a datum plane was assumed as near mean low water at Darien as could be estimated, with the intention of determining the true elevation of this plane on arrival at that place. This was done by reading a gauge for ten days and reducing the low water thus determined to mean low water by a comparison of these readings with readings of the same date taken at Fort Pulaski on a self-registering gauge, the mean low water of which has been determined by five or six months' readings. While this is not absolutely correct, it must be very nearly so. This determination made my plane of reference 17 feet too low. At Macon and Milledgeville elevations were obtained from the Georgia Railroad, which were supposed to refer to about this

level. On comparing these two elevations at the forks of the rivers, a difference of 0.96 feet was found. Assuming that the railroad levels were correctly run from Macon to Milledgeville then there would be an error of 0.96 feet in 352 miles of river survey. According to my determination the datum plane of this road is about 10 feet below mean low water at Darien. Elevations furnished to Mr. Brown at Augusta by this same company were found to be about 15 feet too large. At the Central Railroad crossing of the Oconee River, elevations furnished by the Central Railroad Company proved to be 47.7 feet too small. As the datum of this road is known to be between 42 and 45 feet above mean low water and as the grade at this point is known to have been raised 3 or 4 feet, this difference is about what it should be.

At the crossing of the Savannah, Americus and Montgomery Railroad just above Mount Vernon, elevations furnished proved to be 4.4 feet too small, as referred to mean low water determined as before stated. The elevations furnished at Abbeville, referred to the same plane, were 5.3 feet too small. Assuming the railroad survey to have been correctly run from the Mount Vernon crossing to Abbeville, there would be an error of 0.9 feet in 123 miles of river survey. Assuming as before that the Georgia Railroad survey was correctly run, and figuring around the whole circuit of the two rivers and the two railroads, there would be an error of 0.01 feet in 230 miles of river survey. This would seem to indicate that the two railroad surveys contain opposing errors, and that the river surveys are practically correct. I would also state that in continuing these levels down the Altamaha River a difference of 1.5 feet was found at Doctortown between my elevation of the base of rail referred to mean low water at Darien and that given by the Savannah, Florida and Western Railway.

The total fall from Milledgeville to the Forks is 158.5 feet, and the distance is 149.3 miles, making an average fall of 1.06 feet per mile. The fall between the Georgia Railroad bridge at Milledgeville and the highway bridge is 7.3 feet, and the distance is 2.5 miles, making a fall of nearly 3 feet per mile. A little farther up the river a fall of about 40 feet in 4,000 was found. For further information on this part of the river see Mr. Locke's report of a survey made in 1885.

It will be seen from the accompanying profile or from the following table that while there are many local inequalities the general slope of the river is very uniform, being a little flatter on the lower than on the upper half.

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* Which refers to mean low water at Savannah, Ga.

Distances are reckoned in miles above the mouth of the river, elevations refer to mean low water at Darien, Ga.]

Name of place.	Distance.	Elevation of low water.	Name of place.	Distance.	Elevation of low water.
	Miles.	*Feet.*		*Miles.*	*Feet.*
Georgia Railroad bridge	149.2	247.7	Long Wrestle Jack Bight	50.7	134.6
Milledgeville	146.9	241.9	Gay's Bight	50.5	134.2
Rattlesnake Hill	145.4	239.4	Walton's Landing	50.1	133.7
Camp Creek	142.9	235.6	Short Wrestle Jack Bight	48.5	132.3
Tucker's Ferry	137.4	231.2	Rifle Cut	48.2	131.9
Whitaker's Island	127.3	221.1	Vicker's Hole	47.9	131.6
Town Creek	127.1	221.0	Caney Island Cut	46.9	130.6
Sweeney's	125.0	219.0	Tarr Bluff	45.4	128.6
Raft	120.7	214.8	Dixon's Landing	45.2	128.6
Spring Lake	113 8	202.4	Odam's Ferry	44.3	128.4
Buffalo Creek	108.0	193.0	Louse Bluff	43.9	128.2
Central Railroad bridge	107.7	192.6	Bass Lake	42.5	126.8
Whirligig	105.7	189.7	Silver Bluff	41.6	126.3
Commissioner's Creek	105.4	189.1	Red Bluff Creek	41.2	126.2
Tom's Point	103.0	186.1	Red Bluff	40.9	125.8
Ball's Ferry	102.2	184.7	Williams Bluff	40.2	125.0
Wing Jaw Bright	98.3	179.6	Odam's Landing	38.6	123.0
Thompson's Ferry	98.0	179.3	Center Cut (upper end)	38.0	122.4
Parson's Shoal	96.3	178.3	Adam's Landing	36.8	120.6
Big Sandy Creek	95.3	176.6	Cypress Creek	36.5	120.3
White Bluff	94.0	175.3	Walton's Bar	35.7	119.0
Kittrell's Landing	93.4	174.9	Carroll's Bluff	35.1	118.5
Buckeye Creek	89.6	171.3	Little Oaky Bluff	34.3	118.2
Guyton's Bluff	88.2	169.4	Bear Creek	32.7	116.4
Hobb's Boat-Yard	85.7	167.0	Joyce's Bluff	32.1	115.4
Blackshear's Ferry	85.0	166.6	McMillan's Bluff	30.8	115.0
Blackshear's Landing	84.7	166.4	McMillan's Creek	30.7	115.0
Carr Shoal	84.0	165.8	Savannah, Americus and Montgomery Railroad Crossing	29.9	114.4
Dominey's Landing	83.3	164.1	Lammon's Ferry	29.3	114.2
Big Creek	81.2	162.5	Okeewaukee Creek	28.9	114.0
Keene's Landing	79.9	161.3	Birds' Cut	27.0	111.0
Dublin	79.0	160.6	Pig Pen Bight	26.5	110.2
Row's Landing	77.6	160.3	Stalling's Bluff, Mount Vernon	25.7	109.9
Long Branch	77.0	160.2	Adam's Landing	24.6	109.2
Fuller's Landing	76.0	159.9	Mitchell's Lake	24.3	109.1
Berch's Landing	75.7	159.8	Salt House	23.8	108.7
Little Buzzard Bar	74.2	159.3	McLeod's Cut	22.2	107.6
Big Buzzard Bar	73.8	158.6	Frying Pan Cut (upper end)	20.8	106.7
Drowning Cow Bight	73.2	157.9	Gardon's Cut	19.0	105.0
Fish-Trap Cut	72.7	157.1	Squirrel Jump	18.7	104.5
Clark's Landing	71.8	155.6	Ocmulgee Cut (lower end)	18.7	104.0
Troop Lake	70.8	155.0	Frying Pan Bight	17.9	102.7
Pue's Creek	69.9	154.5	Clark's Bluff	16.1	100.2
Pritchett's Landing (Smith Lake)	69.7	154.4	McArthur's Landing	14.7	98.5
Wring Jaw Bight	68.4	152.6	Browning's Landing	13.7	97.8
Turkey Creek	68.0	151.7	Browning's Old Field	13.4	97.4
Poor Robin Bluff	67.7	151.6	Double Lapsys	12.0	95.0
Pine Lake	67.3	151.2	Lapsys Cut	10.9	94.8
Walton's Landing	66.8	150.8	Lapsys Landing	10.6	94.4
Green's Folly	65.0	148.3	Bob's Landing	9.7	92.9
Shady Field Cut	63.9	146.7	Polley's Cut	8.6	91.6
Shady Bluff	63.6	146.6	Singleton's Cut	8.1	90.8
Flat Creek	63.0	146.0	Steam-boat Bight	7.6	90.2
Cooper's Landing	61.6	144.6	Chaney's Ferry	6.3	88.3
Hall's Warehouse	61.5	144.5	Quinn's Shoal	5.8	88.0
Cooper's Bight	60.0	143.5	White's Landing	4.4	86.9
Branch's Landing	58.1	141.1	Devil's Elbow (Moses Lake)	3.7	86.2
Mercer's Creek	57.0	139.9	McRae's Eddy	2.5	84.9
Upper Travers Bight	56.7	139.6	Bell's Ferry	2.1	84.8
Berry Hill	55.5	138.1	Old Boat Yard	0.9	84.2
Davis' Landing	55.0	138.0	Forks	0.0	82.85
Bonny Clabber	52.6	136.1			
White Water Creek	52.0	135.8			

The discharge measurements were taken with rod floats, using surface floats in shoal water. A straight clear bank was selected and a base line measured off on shore parallel to the current. At both ends and in the middle of this line soundings were taken all of the way across the river on range lines set at right angles to the base line and were located on these lines by intersections of a transit taken at signals given at each sounding when the sounding rod was on range. The instrument was then placed at the upper end of the base line, and as the rods came to the range at right angles to the base the time was noted and the distance from the instrument

taken with a stadia rod. When the lower range was reached the time was taken again and also an intersection with the transit. This, then, gave the distance traveled by the rods, direction of the current, and velocity of the rod. At Milledgeville this work was done just above the highway bridge, as noted on the map. The gauge at the bridge read 7.15 feet. Low water on this gauge is about 1.5 feet. At Dublin and Bell's Ferry the work of determining the discharge was done at low water. The location of these sections are shown on the accompanying maps. The velocities were reduced by the following formula, which is a modification of one deduced by J. B. Francis:

$$Vm = Vr\,[1 - 0.116\,(\sqrt{D} - x)]$$

where Vm = mean velocity of vertical section.

Vr = observed velocity of rod.

$$D = \frac{l}{d}$$

d = depth of river.

l = length of rod (under water).

$$x = f\frac{l}{d}$$

When $\frac{l}{d} = 0.9$ use $x = +0.10$

when $\frac{l}{d} = 0.8$ use $x = +0.05$

when $\frac{l}{d} = 0.7$ use $x = 0.00$

when $\frac{l}{d} = 0.6$ use $x = -.05$

when $\frac{l}{d} = 0.5$ use $x = -0.10$

From the accompanying sections and the following tabular statements the method of working up these notes will be readily seen.

Milledgeville, Ga.—Discharge measurements: Velocities.

Number of observations.	Time.	Distance traveled.	Distance from base line.	Vr.	Vm.	Float submerged.	Depth of water.
	Secs.	*Feet.*	*Feet.*			*Feet.*	*Feet.*
1				Lost.			
2	64½	200	25	3.12	3.06	7.5	8
3	58	200	50	3.55	3.38	7.5	9.5
4	51	200	75	3.92	3.74	7.2	8.3—9.7
5	53	200	160	3.77	3.60	7.2	8.8—9.4—8.4
6	52	200	195	3.85	3.67	7.2	9.8—8.5
7	55	200	235	3.64	3.49	7.2	8.6—8.2
8	55	200	48	3.64	3.43	7.2	9.5
9	51	200	75	3.97	3.74	7.2	8.3—9.7
10	53	200	90	3.77	3.64	7.2	8.0—8.5
11	57	200	160	3.51	3.35	7.2	8.8—9.4—8.4
12	56	200	195	3.57	3.40	7.2	9.8—8.5
13	54	200	160	3.70	3.53	7.2	8.8—9.4—8.4

Milledgeville.—Sections and discharge.

Part of section.	Area.	V*m*.	Cubic feet per second.
Bank to J	214.4	1.50	321.6
J to 7	243.2	3.49	848.4
7 to 6 and 12	336.0	3.51	1,179.4
6 and 12 to 5 and 13	304.0	3.53	1,073.1
5 and 13 to 10	595.2	3.58	2.130.8
10 to 4 and 9	128.0	3.69	462.3
4 and 9 to 3 and 8	220.8	3.58	790.5
3 and 8 to 2	236.8	3.24	767.2
2 to shore	124.8	1.85	230.9
Total	2,403.2	*3.25	7,804.2

*Computed mean.

Dublin, Ga.—Velocities.

Number of observations.	Time.	Distance traveled.	Distance from base line.	V*r*.	V*m*.	Float submerged.	Depth of water.
	Sec.	*Feet.*	*Feet.*			*Feet.*	*Feet.*
1	208	200.0	52	0.96	.90	4.8	8 -6 -7.2
2	217	200.0	52	0.92	.86	4.8	8 -6 -7.2
3	182	200.0	83	1.10	1.03	4.8	8 -6.6-6.5
4	170	200.2	36	1.18	1.09	4.05	6.2-6.0-7
5	162	200.0	59	1.23	1.13	4.05	8.5-6.1-5.7
6	152	200.0	69	1.32	1.22	4.05	7.4-6.2-6.0
7	140	200.5	104	1.43	1.33	4.05	7.9-5.6-6.3
8	124	200.9	141	1.62	1.52	4.05	5.7-5.3-6.0
9	109	201.0	182	1.84	1.73	4.05	5.0-5.8-5.3
10	118	201.0	220	1.70	1.58	4.05	5.5-5.8-5.3
11	118	201.0	237	1.70	1.58	4.05	6.2- 4.9
12	109	201.8	187	1.84	1.73	4.05	5.0-5.7-5.1
13	148	200.5	112	1.36	1.25	4.05	7.7-6.2-6.3

Dublin, Ga.—Sections and discharges.

Part of section.	Areas.	V*m*.	Cubic feet per section.
	Sq. feet.		
Shore to 4	169.6	{1 @ .60 {3 @ 1.18	171.4
4 to 5	153.6	1.11	170.5
5 to 6	80.0	1.17	93.6
6 to 7	240.0	1.28	307.2
13 to 7	44.8	1.29	57.8
8 to 13	214.4	1.38	295.9
8 to 9	211.2	1.62	342.1
9 to 12	44.8	1.73	77.5
12 to 10	169.6	1.65	279.8
10 to 11	89.6	1.58	141.6
11 to shore	67.2	0.79	53.1
Total	1,484.8	*1.34	1,990.5

* Computed mean.

Bell's Ferry.—Velocities.

Number of observations.	Time.	Distsnce traveled.	Distance from base line.	V*r*.	V*m*.	Float submerged.	Depth of water.
	Sec.	*Feet.*	*Feet.*			*Feet.*	*Feet.*
1	144	200	62	1.38	1.27	5.7	8.3-10.7-10.6
2	149	200.5	156	1 34	1.24	4.0	4.8- 5.8- 7.5
3	158	206.2	218	1.31	1.23	0.0	5.5
4	204	203.5	292	1.00	0.95	0.0	6.0
5	190	204.0	255	1.07	1.03	0.0	5.0
6	235	203.5	297	0.86	0.81	0.0	8.0
7	233	203.8	302	0.87	0.80	4.0	7.5- 7.0- 6.5
8	146	200.0	73	1.37	1.26	5.7	8.0- 9.7-10 5
9	151	200	109	1.32	1.26	5.7	6.0- 7.8- 9.3
10	203	209	166	1.03	0.96	4.0	7.0- 4.9- 4.9

Bell's Ferry.—Sections and discharges.

Part of section.	Areas.	V*m*.	Cubic feet per section.
	Sq. feet.		
7 to shore	99.2	0.51	50.6
7 to 4	86.4	0.88	76.0
4 to 5	259.2	0.99	256.6
3 to 5	198.4	1.13	224.1
3 to 2	332.8	1.23½	411.0
2 to 9	326.4	1.25	408.0
9 to 8	304.0	1.26	383.0
8 to 1	112.0	1.26½	141.7
1 to shore	281.6	0.82	230.9
Total	2,000.0	*1.09	2,181.9

*Computed mean.

Mr. Van Ornum found at Lumber City that—	cubic feet per second.
The discharge of the Ocmulgee River at a stage four-tenths of a foot above the stage at which my work was done was	2,626
Reduction for 0. 4 inches	182
Ocmulgee River	2,444
Oconee River	2,182
Total	4,626

At Town Bluff on the Altamaha, about 2 miles below the Forks I found by the same method a discharge of 4,727 cubic feet per second. This leaves 101 cubic feet per second for the discharge of the Little Ocmulgee, which is probably about correct. Mr. S. A. Cook, of Milledgeville, gave me the following table showing rain-fall at that place for seven years, which he says "represents an average for nearly twenty years."

Rain-fall at Milledgeville, Ga.

Month.	1883.	1884.	1885.	1886.	1887.	1888.	1889.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
January	4.62	5.20	8.37	7.31	3.73	6.30	6.93
February	5.20	4.95	3.39	1.56	5.35	6.34	5.20
March	7.65	8.87	3.32	5.71	2.07	10.81	3.19
April	4.11	4.51	.98	1.29	1.77	.99	4.30
May	2.15	1.69	6.69	2.59	3.17	5.88	.72
June	1.85	7.64	4.06	10.97	1.47	2.66	2.46
July	1.52	2.52	3.04	4.08	16.09	2.44	9.21
August	3.88	3.38	7.70	5.54	3.86	4.60	4.04
Sep ember	.59	0.00	9.38	.59	1.47	11.00	2.50
October	1.92	.69	4.80	0.00	5.33	6.16	.....
November	2.10	1.99	1.74	2.88	1.13	4.41	.....
December	4.20	5.87	2.66	3.40	5.92	5.60	.....
Total	39.79	47.31	56.03	45.92	51.36	67.19	.....

Mean for 1883–1888=51.3 inches. Average rain-fall for twenty years=51 inches.

The rain-fall for the month of July, 1887, in the northern part of the State was unusually heavy as will be seen from the following tabular statement:

Place.	1st to 12th.	12th to 27th.	27th to 31st.	Total for month.
	Inches.	*Inches.*	*Inches.*	*Inches.*
Milledgeville	5.75	0.36	9.98	16.09
Macon	1.15	1.30	3.39	5.84
Augusta	.....	.....	5.50	8.22
Union Point	.....	.....	.....	18.13
Washington	.....	.....	.....	15.95
Athens	.....	.....	.....	15.93
Atlanta	.....	.....	.....	14.11
Camak	.....	.....	.....	13.46

Assuming a yearly rainfall of 51 inches and that 50 per cent. of all that falls finds its way into the river for the drainage area above Milledgeville, there would be an average flow of 4008 cubic feet per second at Milledgeville. Assuming that 40 per cent. of what falls in the valley below Milledgeville finds its way into the river, there will be an average discharge of 7317 cubic feet per second, at the Forks. As the low-water discharge is 2182 cubic feet per second, it will be seen that the discharge during freshets must be very large. At Milledgeville a survey was made of the section of the valley up to the high-water mark of 1887, with a view of obtaining the discharge at that place during the greatest flow. Assuming a velocity about equal to what has been observed under similar conditions on other rivers, a discharge of about 300,000 cubic feet per second is obtained. From the above tables it will be seen that about 10 inches of water fell in about three days. Assuming that three-quarters of this ran off in the same length of time that it took to fall, would give a discharge at Milledgeville of 120,000 cubic feet per second. It is, therefore, probable that there must have been some eddy water in the Milledgeville section when the water was at its highest, and that results obtained by any other method than by actual observed velocities can not be used at that point.

The gaugings at this point show that when the river is about 4 feet above low water the discharge is then equal to about the mean for the entire year.

A month before this survey was begun a permanent gauge was established at Milledgeville, and about the time that work began one was established at Bell's Ferry, near the Forks. During the progress of the works others were established at Oconee Station and at Dublin. All of the readings on these gauges have been plotted on profile paper, assuming a low-water line for each one and plotting them all with reference to this line. From this it will be seen that during the middle of October last nearly all of the gauges were at this assumed low-water line. During this period there was very little rain, either in the upper or lower part of the river. This shows that my assumptions are consistent; and from statements of people living along the river I infer that this low water was about the ordinary summer low water. The disagreement between the low waters in December was probably due to the unequal rainfall in the upper and low rivers.

The progression of ordinary high water, as shown by these readings, is, roughly, 1 mile per hour. The velocity of the surface water at these times, however, is greater than that, as the observed velocities at low water were nearly 1 mile per hour. At some places the flat drifted at the rate of about one-half mile per hour, and at other places it went as fast as 3 miles per hour. At Carr Shoals (although no velocities were taken) I think the water runs for a short distance at the rate of about 6 or 7 miles per hour. Steam-boats are compelled to get a line out at this point to help themselves over the shoals.

GENERAL DESCRIPTION.

The Oconee River is about 300 miles in length and drains an area of about 5,400 square miles, of which about 2,790 lie above Milledgeville. It rises near Gainesville and flows in a southeasterly direction, joining the Ocmulgee to form the Altamaha.

The northern portion of the valley contains some of the best farming land in the State of Georgia; and while the southern portion is a good farming country, it contains large quantities of valuable pine timber. From Milledgeville down the river bottom itself a strip of from 2 to 4 miles wide has large quantities of oak, maple, elm, gum, and cypress, all of which will be valuable some time in the future.

From Milledgeville to Camp Creek the country is quite open, the valley narrow, and the banks high. At Camp Creek the valley widens out and has more the appearance of a swampy country. The banks are low and timber is much more abundant. The general characteristics of the river from here down are very much the same. In fact, the river-bed is the result of the windings of a small river in a large flat river bottom. The valley is mostly composed of a sticky alluvial clay with a considerable mixture of sand. In some places there is considerable rock exposed at the surface of the ground. Where rock is found in the river bottom it is mostly in ledges having a dip of about 30 degrees. Wherever the valley is a little steeper in slope than the average the river-bed becomes more crooked, and where the general slope is less the river has straight reaches. In some places, however, the straight reaches are caused by a rocky bottom or bank, the river not being able to adjust its slope in such cases.

The main difficulty is due to the unequal flow of water at the different seasons of the year. The immediate effect in this case is a very rapid erosion of the banks in the bights, and the banks being quite heavily timbered, the river is constantly being filled up with trees and brush. These trees, being mostly hard wood, stay where they fall, and if not removed soon stop navigation entirely. Another injurious effect of freshets is the washing out of wide places in the river, the velocity at those points being reduced so much when the water goes down that the maintenance of a channel as deep as at other places is not possible. These sand-bars are constantly changing,

owing to the constant variations that are taking place in widths and slopes all along the river. On comparing my map with some old ones I notice some places that were spoken of as bad shoals that now have 8 or 10 feet of water, showing that the bars complained of had entirely washed away.

DESCRIPTION OF MAPS.

On the accompanying maps "low water" does not mean the lowest summer low water, but an average summer low water, which is probably 1 foot above extreme summer low water. And the figures given in this report do not refer to the river in its worst condition, but as it will ordinarily be found at low summer stages. The figures on the part from Milledgeville to the Central Railroad Bridge are not as reliable as those on the balance of the river, because I was compelled to do that part of the work when the river was up 5 or 6 feet. And it is impossible to tell what water there would be at low water under such circumstances, for two reasons: First, the constantly varying widths and velocities make the height the water is above low water a constantly varying quantity; second, on sand-bars the absolute height of the bottom changes when the water falls.

On the general profile of the river I have shown the heights of low water as well as the water surface when the work was done. The freshet line for 1887 is also shown, but is not very reliable, as in most instances I was compelled to determine it by marks left on trees. The profile of the bottom is also shown, and I have added from Mr. Locke's survey the water-line and bottom up to Skull's Shoals. The points occupied by rod and transit were numbered consecutively from 0 to 747, and are so placed on the maps.

MILLEDGEVILLE TO CENTRAL RAILROAD BRIDGE.

From Milledgeville to the Raft there is plenty of water; but trouble may be experienced at the former place at very low water. Just at the head of the island below the highway bridge there is a depth of only about 4 feet of water, and as it was reported that trouble was experienced here at very low water this place should be improved. It is sand bottom with some small rocks intermingled. The direction of the current is toward the west side of the island, but the greater part of the water goes on the east side, the channel on that side being the wider. The fall here is 0.15 foot in 400 feet.

The reach just below this island has only about 5 feet of water, and might cause trouble at very low water. The bottom is sand, the fall 1.61 feet in 4,000 feet. No improvement is here recommended.

The raft is an accumulation of logs, trees, timber, and drift-wood. The heavier portion of the trees and timber remains on the bottom and thus prevents freshets from washing it away. This raft must be of recent formation, as Mr. Gould makes no mention of it in his report of an examination made by him in 1874, yet the lower part of the raft is considerably grown up with willows. The water being up while I was at this place, it was impossible to make a close estimate of the material to be removed, but as near as I could judge there were about 3,000 pieces, mostly trees. It is my opinion, however, that it would be cheaper to move this material than to make a cut around it, as the shortest possible cut would be about 800 feet. The fall is so great here (about 2½ feet) that a cut would not be admissible. A dam at the upper end of the raft closing Sweeney's Cut should be made, length 100 feet. Considerable water goes through this cut, but it being all choked up with fallen trees, no boats can pass this way. It is enlarging very rapidly.

A cut-off at station 155 needs a closing-dam. Very little water gets through at low water, but as high water goes straight across this elbow it is cutting out. The opening is now 40 feet wide and the distance in a straight line across the elbow is 600 feet.

The old river at station 170 ought to be closed. This river is 100 feet wide, about 10 feet deep in the deepest part, and draws about one-third of the water.

A small suck at station 176 about 20 feet wide should be closed. The distance across the elbow is here nearly 100 feet.

At station 217 there is a sudden widening of the river that may cause trouble, but as there is now not less than 4.5 feet of water no work is at present needed.

At station 239, just above the Central Railroad Bridge, a shoal has formed on which there is a depth of only about 4 feet at low water, of sufficient width for boats to pass. This shoal was evidently produced by the division of the flow of water at this point, as about one-half of the water now goes down the old river. The old river is 200 feet wide and about 4 feet deep. No other improvement than the closing of the old river will be needed here.

There are upon this section of the river about 8,000 feet of shore-line that should be protected. The places that need protection are of two distinct classes: First, to prevent the river from making cut-offs; second, to prevent dangerous widenings of the river. Places of the first kind that need protection on this part of the river are at the following points: At stations 86, 98, 106, 118, 166, 176, 188, 196, 201, 205, and 221. Those of the second class that need protection are located as follows: At sta-

tions 209, 224, 236, and 240. There are 450 logs, trees, etc., to be removed from this section of the river.

It is estimated that the sum of $19,204 will be necessary to improve this portion of the river.

There has never been any regular line of steamers on this section of the river, most of the freights going down in flats, which were not taken back to be reloaded. Should a line of steamers be put on, it is not likely that it would secure anything but the cotton trade, the country being so well provided with railroad transportation. There is so little pine timber on this portion of the river that it is not worthy of improvement for that reason.

CENTRAL RAILROAD BRIDGE TO DUBLIN.

This portion of the river has been recently operated by a regular line of steamers and is now used occasionally to deliver and receive local freights only; no boats now running to the bridge. This bridge is of the Howe-truss type, through, covered, and has no iron except for vertical tension members. It was built in 1840 and is now in a dangerous condition. The two river piers are of brick, the west pier being stone and the east end supported by two strong trestle bents.

This part of the river differs from the part to Milledgeville, in that there are a good many rock shoals to deal with. About 6 miles below the bridge (at Ball's Ferry) pine timber begins to be abundant, and it is to this point that steam-boats now run.

There are now about two hundred and thirty trees, snags, logs, etc., that need removing.

The first place that would give any trouble is at Tom's Point, where a cut-off has formed which draws about one-half of the water, thus causing a bad shoal. This shoal is about 300 feet long and has only 3 feet of water in the worst place. The bottom is sand, and the only improvement that will be necessary will be to close the old river, which is 250 feet wide and from 2 to 4 feet deep.

A cut-off has started to form at Station 284, which is 40 feet wide and dry at low water.

At Parson's Shoals there is now a channel 50 feet wide and 4.5 feet deep. But as this is close to the bank, has rock bottom, is rather crooked, and has a steep slope (.9 feet in 1,000 feet), it is estimated that 200 cubic yards of rock should be removed to make this point less dangerous to steam-boats. This rock is not in ledges, but is small, loose rock.

At Station 329 the river has widened out so much as to form a bad shoal. The river here is 450 feet wide from bank to bank, width of low-water surface being about 300 feet. There is a depth of only 3 feet of water for a distance of about 90 feet and 4 feet for a distance of 400 feet. The bottom is of sand and the banks are about 8 feet high.

Carr shoal is in good condition but will require the removal of a few yards of rock at the lower end.

Besides the places mentioned above, there are several places where ledges crop out, giving water enough at ordinary low water, but requiring improvement in order to guard against trouble at extreme low waters. These places are as follows:

At or about station—	Cubic yards of rock to be removed.	Present depth of water.
287	40	4.0
313	40	4.5
351	100	4.0
353	20	4.0
355	100	4.5
358	50	4.5
359	100	4.0
362	100	3.5
367	30	4.0
Total	580	.....
Parsons's Shoal	200	.....
Total rock	780	.....

The shore-line on this section of the river should be protected at the following points: Station 284, to prevent the formation of a cut-off; stations 256, 269, 286, 329, 332, and 337, to prevent widening of the river and consequent shoaling.

It is estimated that the sum of $7,490 will be necessary to improve this portion of the river.

DUBLIN TO THE FORKS.

To improve this part of the river will be more expensive than the first half, owing to the fact that there is more timber to be transported, and the jetties and shore protection must therefore be made more substantial. There is not so much rock to be removed; but there are more sand-bars to be improved and cut-offs to be closed.

Aside from some little rock to be excavated, the first bad place is Little Buzzard Bar. The river here is very wide, 300 feet from bank to bank, but is only 150 feet wide from the east bank to the exposed sand-bar. The bottom is sand and there is a depth of only 3.5 feet of water for a distance of 50 feet and 4 feet for a distance of 200 feet.

Big Buzzard Bar is not as bad as Little Buzzard Bar, as it has 4 feet of water. The bar here is of very coarse sand; the river is 330 feet wide and the water-way 180 feet wide. The banks at both of these bars are about 8 feet high.

At Station 389 the river widens out to about 400 feet, and is in consequence, quite shoal, there being about 4 feet of water for a distance of 300 feet. The channel is so close to the point here that boats have difficulty in keeping out of the bight, in which there is a depth of only 2.5 feet of water. To prevent this and to guard against future shoaling works of contraction will be needed here.

Two closing dams at the upper end of Fish Trap Cut will be needed in order to secure more water at the lower end of the cut. They will be 100 and 30 feet long respectively. Depth of water about 4 feet.

A sand-bar, 100 feet long, has formed at the lower end of Fish Trap Cut, on which there is a depth of only 3.5 feet of water. While the closing dams above mentioned will help this shoal, jetties will also be needed at the bar itself.

At Poor Robin Bluff the river has widened out to 400 feet and a sand-bar more than 200 feet long has formed on which there is a depth of only 3.5 feet. The banks are about 7 feet high here. Jetties will be needed to confine the flow to a narrower channel.

At the mouth of Flat Creek the river is wide, about 230 feet, and a short sand-bar has formed on which there is a depth of only 3.5 feet for a distance of 30 feet and 4 feet for a distance of 200 feet.

At station 484 an exposed sand-bar has formed in the middle of the river and some water flows on each side of it, although the greater portion goes on the east side. The water on this side is 150 feet wide and there is a depth of 3.5 feet of water in the channel for a distance of 100 feet. There is also a small suck 15 feet wide opposite this bar.

At Rifle Cut so much of the water still goes into the old river as to cause a shoal to form at the point where the water divides. There is now a depth of only 4 feet of water for a distance of 100 feet at this place. No other improvement than the closing of the old river will be needed. This opening is 220 feet wide and from 2 to 6 feet deep.

Just below Odam's Ferry, at station 533, there is a long flat sand-bar on which there is a depth of only 3.5 feet of water for a distance of 500 feet. The river is about 260 feet wide here and the fall much less than the average. The bottom is of fine sand and the banks are high, 8 or 10 feet.

At Red Bluff the river is very wide (about 400 feet) and there is a depth of only 4 feet of water for a distance of 500 feet. The bottom is of sand and the slope very small. There are two places just below this on which there is a depth of only 4 feet of water, aggregating a distance of 300 feet. These places have about the amount of water called for in the letter of instructions and no improvement is here recommended.

There are three places in "Center Cut" which have only 3.5 feet of water for a distance of about 100 feet each, and one where there is only 3 feet. The river through the cut is very narrow and crooked. Its total length is 5,880 feet and the fall is 2 feet. The bottom is of sand and the banks are about 5 feet high. Not more than one-half of the water goes through the cut. The old river at the upper end is 250 feet wide and the water from 2 to 8 feet deep. The only improvement that will be needed here will be a dam to close the old river, and some shore protection in the cut to prevent undue widening of the river.

At Walton's Bar a short but bad sand-bar has formed. There is at present a depth of 3 feet of water for a distance of about 30 feet and 3.5 for a distance of 150 feet. The river is wide (about 300 feet) and the banks are high. Works of contraction will be needed here.

At Ocmulgee Cut a closing dam should be put across the old river 100 feet in length and in about 7 feet of water. The two points of the cut should be dredged off a little.

At the lower end of Frying Pan, at Station 664, a bad sand-bar has formed in a very narrow river. This bar is in the middle of the river, with a very narrow channel on both sides of it. There is 2.5 feet on the bar and 3.5 feet where boats would have to run. One channel or the other must be closed by contraction works, as there is not water enough to maintain both.

At and just below Browning's Landings there is a depth of 4 feet and 3.8 feet of

water over short sand-bars, but no improvement is recommended, as these places have just about the amount of water asked for.

At Station 690 the river widens out suddenly to 375 feet, which has caused a sand-bar to form, having only 3.5 feet of water on it for a distance of about 100 feet. This place should be narrowed by jetties.

At Section 701 a sand-bar has formed on which there is a depth of only 3.5 feet of water for a distance of 50 feet and 4 feet for a distance of 300 feet. The water-way here is very wide (300 feet), and the place can therefore be easily improved.

The sand-bar formed just above Steam-boat Bight is a long and bad one, having only 3 feet of water for a distance of 800 feet. The water here is a little deeper at both sides than in the middle, being only 2 feet deep in places and not less than 3 feet in the channel. This place must be improved by jetties and shore protection. There will also be needed a closing dam 50 feet long.

Chaney's Shoal has a cut through it in which there is now a depth of 4 feet of water. This cut is so close to the bank as to cause trouble to steamboats. It should be widened a little and at the same time deepened five or six inches. This rock is in nearly horizontal layers and is very soft.

Quinn's Shoal is a rocky ledge on which there is a depth of only 3.5 feet of water. This shoal should be improved by rock jetties instead of making a cut, because lowering the pool above would make one continuous shoal of it with only about 4 feet of water.

The lower end of Floating Mill Reach has only 4 feet of water and may give trouble when the water gets very low. No improvement of this part of the reach is recommended, it now having the depth of water called for.

At Bryant's Floating Mill there are two shoals, one of rocks and one of sand. The upper one is of rock and has 4 feet of water for a distance of 200 feet. The river is wide here and has an island in the middle, the main body of water going on the west side of the island. If the east side were closed by a rock jetty no other improvement would be needed. The sand bar just below this is not a bad one, there being 3.5 feet of water for about 50 feet and 4 feet for a distance of 300 feet. The river being wide here, a pile and brush jetty will be needed.

At the old boat yard a bad sand bar has been formed by the river suddenly widening out to about three times its proper width. This widening is said to have been produced by the freshet of 1887. This shoal has only 2 feet of water at the crest of the bar and is about 600 feet long. This is the worst place on the whole river and will be expensive to improve.

Besides the places mentioned above there will be closing dams needed on this section of the river, as follows:

At station—	Length required.	Depth of water.	At station—	Length required.	Depth of water.
	Feet.	*Feet.*		*Feet.*	*Feet.*
489	30	2.0	700	60	4.0
504	10	1.0	703	30	0.0
514	16	2.0	705	30	0.0
538	50	0.0	712	100	6.0
634	60	3.0			
653	10	1.0	Total	420	.....
654	30	2.0			

There will be six hundred and forty trees, logs, and snags to be removed.

Places that need shore protection on this section, to prevent cut-offs being formed, are as follows: At stations 423, 467, 479, 487, 502, 514, 538, 543, 617, 627, 632, 670, and 703. Places that should be protected to prevent widening of the river are as follows: Stations 384, 386, 389, 390, 391, 405, 421, 430, 434, 437, 495, 499, 515, 544, 555, 565, 566, 568, 571, 579, 618, 648, 660, 690, 714, and 730.

These places will require about 15,000 lineal feet.

Rock excavation will be needed on this portion of the river at the following places:

At station.	To be removed.	Present depth of water.	At station.	To be removed.	Present depth of water.
	Cub. yds.	*Feet.*		*Cub. yds.*	*Feet.*
371	50	5.5	719	40	4.5
391	50	4.0	721	200	4.0
534	40	3.5	724	100	4.0
602	60	4.5	732	50	4.8
631	50	4.0			
718	150	4.0	Total	790	

Besides the above there will be about 300 cubic yards of rock needed for jetties at Quinn's Shoal and about 100 cubic yards at Bryant's Floating Mill.

It is estimated that the sum of $40,415 will be required to improve the river from Dublin to The Forks.

For the whole river there will be needed the sum of $87,020.

This is only considered sufficient to put the river in good condition for the navigation of boats drawing 3 feet at low water; but as the water is far above low water for the greater part of the year boats that are capable of being loaded to 5 or 6 feet could be used to advantage, loading to only 3 feet during very low water.

Should it be decided not to improve the part of the river from Milledgeville to the Central Railroad Bridge then the total amount required will only be $65,895. But, owing to the frequent freshets and unstable condition of the banks of the river, and consequently constant filling of the river with trees and snags, there must be work done on the river every year to keep it in condition for steam-boat traffic. A snag-boat would be required for about five months each year, at $900 per month, making $4,500. Besides this there is a liability of some of the jetties or closing-dams being carried away by freshets, and an annual allowance of $1,000 for their repair should be made, making an annual expenditure of $5,500 to keep the river in good condition when that state of affairs is once secured.

The following table contains a statement in brief of all the places mentioned in the foregoing report, except places where shore protection is needed:

Number.	Sheet.	Station.	Distance from the forks.	Name of place.	Slope per 1,000.	Depth of water at summer low water.	Width of river.	Length of obstruction.	Radius of curve.	Height of banks.		Cubic yards of rock to be removed.	Character of bottom.	Remarks.	Improvements recommended.
										West.	East.				
			Miles.		*Feet.*	*Feet.*	*Feet.*	*Feet.*		*Ft.*	*Ft.*				
1	1	10	146.5	Fishing Creek	.37	4.0	140	400	900	9	10	.....	Sand and rock.	Water divides at head of island.	Closing dam 200 feet long.
2	1	11	146.0	.....	.40	5.0	300	4,000	8	12	9	.....	Sand.....	Wide and straight reach	Nothing.
3	2	132	120.6	Raft	1.48	.....	175	1,700	500	6	6	.....	.....	About 3,000 pieces, trees, drift-wood, etc.	Should be removed.
4	2	133	121.1	Sweeney's Cut.....	.....	.....	.....	.....	.....	6	6	.....	.....	Cut-off, full of trees, 100 feet wide.	Should be closed.
5	2	155	119.4	.....	.....	.....	.....	.....	.....	5	...	.....	.....	Cut-off 40 feet wide	Do.
6	2	170	117.9	.....	.....	.....	.....	.....	.....	5	...	.....	.....	Old river, 110 feet wide	Do.
7	2	176	117.2	.....	.....	.....	.....	.....	.....	5	...	.....	.....	Cut-off 20 feet wide	Do.
8	3	239	108.7	.....	.....	4.0	250	.....	.....	5	6	.....	.....	Old river, 200 feet wide, draws one-half of water.	Do.
9	3	269	103.0	Tom's Point	.38	3.0	200	300	400	7	5	.....	Sand.....	Old river, 250 feet wide, draws one-half of water.	Do.
10	4	284	99.4	.....	.....	.....	.....	.....	.....	...	...	...	.....	Cut-off 40 feet wide	Do.
11	4	287	99.0	.....	.....	.....	.....	.....	.....	...	...	40	Rock	Exposed rock near channel.....	Should be removed.
12	4	302	96.3	Parson's Shoals.....	.90	4.5	230	300	1,100	7	12	200	...do	Channel is too narrow.....	Should be widened.
13	4	313	93.1	.....	.....	4.5	200	100	.....	...	...	40	...do	Short ledge.....	Should be removed.
14	4	329	90.2	.....	.35	3.0	450	90	1,100	6	8	.....	Sand.....	Bar caused by wide river	Will need brush and pile jetties.
15	5	351	84.6	.....	.....	4.0	250	300	.....	...	...	100	Rock	Loose rock in channel.....	Should be removed.
16	5	353	84.0	Carr Shoals.....	2.00	4.0	300	400	8 8	15	9	20	...do	Loose rock in lower part of cut.	Do.
17	5	355	83.2	.....	.....	4.5	300	400	8 8	10	12	100	...do	Ledges across channel.....	Do.
18	5	358	82.1	.....	.....	4.5	220	200	.....	...	...	50	.. do	Loose rock and in ledges.	Do.
19	5	359	81.8	.....	.....	4.0	230	300	.....	...	...	100	...do	.....do.....	Do.
20	5	362	81.1	.....	.....	3.5	250	500	.....	10	10	100	...do	In ledges.....	Do.
21	5	367	79.5	.....	.....	4.0	250	60	.....	...	..	30	.. do	.....do	Do.
22	5	371	77.9	.....	.....	5.5	250	30	.....	8	10	50	...do	Short ledge	Do.
23	5	384	74.1	Little Buzzard Bar....	.30	3.5	300	50	1,600	7	7	.....	Sand.....	Bar caused by wide river.....	Will need brush and pile jetties.
24	5	386	73.8	Big Buzzard Bar.....	.38	4.0	330	200	1,200	7	7	.....	...do	.....do.....	Do.
25	5	389	73.0	.....	.30	4.0	400	300	300	5	7	.....	...do	Bar caused by wide river and sharp bend.	Do.
26	5	389	72.9	Fish-Trap Cut.....	.....	.....	.....	.....	.....	...	...	.....	.....	Old river, 100 feet wide, draws one-third of water.	Should be closed.
27	5	389	72.8	.....do	.....	.....	.....	.....	.....	...	...	.....	.....	Small cut-off 30 feet wide	Do.
28	5	391	72.5	.....do	.66	3.5	150	100	1,000	8	7	.....	Sand.....	Bar partly due to loss of water by old river.	Should be closed; also brush and pile jetties needed.

29	5	391	72.4	.....	.....	4.0	300	.....	.....	...	...	50	Rocks	Loose rock in cut.....	Should be cleared out.
30	6	408	67.7	Poor Robin Bluff	.16	3.5	400	200	700	9	7	.....	Sand.....	Bar caused by widening of river.	Brush and pile jetties needed.
31	6	434	63.0	Flat Creek.....	.11	3.5	230	30	370	8	5	.....	...do	Bar caused by wide river and sharp bend.	Do.
32	6	484	52.8	.....	.25	3.5	300	100	8	4	6	.....	...do	Exposed sand in center of river.	West side should be closed.
33	6	484	52.8	.....	.....	.....	.....	.....	.....	...	...	.....	.....	Small cut-off 15 feet wide.....	Should be closed.
34	7	489	51.9	.....	.....	.....	.....	.....	.....	...	...	.....	.....	Small cut-off 30 feet wide.....	Do.
35	7	504	49.2	.....	.....	.....	.....	.....	.....	...	...	.....	.....	Small cut-off 10 feet wide.....	Do.
36	7	511	48.2	Rifle Cut.....	.30	4.0	180	100	400	6	6	.....	Sand.....	Old river, 220 feet wide; draws two-fifths of water.	Do.
37	7	514	47.5	.....	.....	.....	.....	.....	.....	...	...	.....	.....	Small cut-off 16 feet wide.....	Do.
38	7	533	44.2	.....	.06	3.5	260	500	8	10	6	.....	Sand.....	Bar caused by wide river and flat slope.	Brush and pile jetties needed.
39	7	534	43.8	.....	.....	3.5	.....	20	.....	...	...	40	Rocks	Short ledge across channel	Should be removed.
40	7	538	43.0	.....	.....	.....	.....	.....	.....	...	...	.....	.....	Cut-off 60 feet wide	Should be closed.
41	7	547	41.0	Red Bluff.....	.07	4.0	400	500	8	6	20	.....	Sand.....	Shoal caused by wide river.....	Nothing.
42	7	548	40.4	.....	.07	4.0	300	300	300	6	6	.....	...do	River wide; bar at crossing from bight to bight.	Do.
43	7	563	38.0	Center Cut	.37	3.5	175	100	400	4	5	.....	; .do	Old river here draws about one-half of water, causing these shoals. Old river, 250 feet wide; cut, 5,880 feet long; all, 2 feet.	Old river should be closed and shore protected.
44	7	568	37.6	.....do	.30	3.5	120	100	200	4	4	.....	...do		
45	7	572	37.1	.....do	.30	3.0	175	150	400	4	4	.....	...do		
46	7	579	35.6	Walton's Bar.....	.35	3.0	300	150	400	5	6	.....	Sand.....	Bar caused by wide river.....	Brush and pile jetties needed.
47	8	602	30.3	.....	.....	4.5	.....	.....	.....	...	...	60	Rocks ...	Loose rocks, rough bottom	Should be cleaned out.
48	8	631	23.7	.....	.....	4.0	.....	.....	.....	...	...	50	...do	Short ledge across channel.....	Should be removed.
49	8	634	23.0	.....	.....	.....	.....	.....	.....	...	...	.....	.....	Cut-off 60 feet wide	Should be closed.
50	8	653	19.4	.....	.....	.....	.....	.....	.....	...	...	.....	.....	Cut-off 10 feet wide	Do.
51	8	654	19.3	.....	.....	.....	.....	.....	.....	...	...	.....	.....	Cut-off 30 feet wide	Do.
52	8	658	18.7	Ocmulgee Cut	1.25	5.0	130	100	{300 / 100}	5	5	.....	Clay	Three turns, last very sharp....	{Two points should be cut away.
53	8	664	18.1	.....	.23	3.5	300	150	8	5	4	.....	Sand.....	Bar formed in center of river...	Brush and pile jetties needed.
54	8	686	13.6	Browning's Landing..	.24	3.8	300	150	1,200	6	7	.....	...do	Bar caused by wide river.....	Nothing.
55	9	690	12.5	.....	.24	3.5	375	100	300	6	6	.....	...do	Bar caused by wide and crooked river.	Brush and pile jetties needed.
56	9	700	10.5	.....	.....	.....	.....	.....	.....	...	...	.....	.....	Cut-off 60 feet wide	Should be closed.
57	9	701	10.4	.....	.22	3.5	270	50	8	5	5	.....	Sand.....	Bar formed in a wide straight reach.	Brush and pile jetties needed.
58	9	703	10.1	.....	.....	.....	.....	.....	.....	...	...	.....	.....	Small cut-off 30 feet wide	Should be closed.
59	9	705	9.6	.....	.....	.....	.....	.....	.....	...	...	.....	.....	.....do	Do.
60	9	712	8.0	.....	.....	.....	.....	.....	.....	...	...	.....	.....	Cut-off 100 feet wide	Do.
61	9	715	7.6	Steam-boat Bight	.30	3.0	200	800	8	4	5	.....	Sand.....	Bar in center of river	Brush and pile jetties needed.
62	9	718	7.1	.....	.....	4.0	200	100	.....	...	...	150	Rock	Ledge across channel.....	Should be removed.
63	9	719	6.9	.....	.....	4.0	240	20	.....	...	...	40	...do	.....do	Do.
64	9	721	6.6	Chaney's Shoal	.10	4.0	250	200	500	9	3	200	...do	Channel too narrow and close to banks.	Should be widened and deepened.
65	9	723	5.8	Quinn's Shoal.....	.10	3.5	300	200	2,000	9	5	.....	...do	Rock shoal in nearly straight river.	Needs two rock jetties.

Number.	Sheet.	Station.	Distance from the forks.	Name of place.	Slope per 1,000.	Depth of water at summer low water.	Width of river.	Length of obstruction.	Radius of curve.	Height of banks.		Cubic yards of rock to be removed.	Character of bottom.	Remarks.	Improvements recommended.
										West.	East.				
			Miles.		*Feet.*	*Feet.*	*Feet.*	*Feet.*		*Ft.*	*Ft.*				
66	9	724	5.5	.....	.....	4.0	.....	100	.....	.....	.....	100	...do	Ledge across channel	Should be removed.
67	9	726	4.9	.....	.10	4.0	300	500	4,400	9	6	.....	Sand.....	Wide river and small velocity..	Nothing.
68	9	732	3.6	.....	.....	4.8	250	20	.....	.....	.....	50	Rocks	Short ledge across channel.....	Should be removed.
69	9	734	2.8	Bryant's Floating Mill	.40	4.0	275	200	8 8	6	10	.....	...do	Island in center dividing channel	East side should be closed.
70	9	735	2.6	.....do	.25	3.5	300	300		6	10	.....	Sand.....	Bar caused by wide river	Brush and pile jetties needed.
71	9	741	0.9	Old Boat-Yard.....	.40	2.0	520	600	2,200	8	15	.....	...do	Bar caused by wide river	Brush and pile jetties needed.

COMMERCE.

The collection of anything like reliable information about the actual commerce in the past or probable commerce in the future is a very difficult matter. In any case, an accurate estimate of this nature is impossible, but in this case an approximate one is difficult, because in many instances no records are kept at all.

The past commerce on this river in its present bad condition is no guide to what it will be if the river is put in a thorough navigable condition. At present there is a great deal of business done on the river that could not be done at all if the river could not be used, and if the river were to be improved there would arise a much larger business that can not now be done successfully with the river in its present condition. The pine timber on this river is nearly all out of the reach of any railroad, and the only way to get this timber out is by river.

Two steam-boats are now running on the river, the *Tommie* and the *Laurens*, either of which will carry about 180 tons of freight. They draw about 3 feet when loaded. There is another boat being built at Dublin which will draw 18 inches when light and can be loaded to any depth up to 6 feet. When fully loaded this boat will carry two or three times as much as those now running. The following table shows what the traffic on the river has been, or such of it as could be obtained:

Name of article.	1880–'81.	1882–'83.	1884–'85.	1887–'88.	1888–'89.
Guano ..... tons	3.000	850	.....	1,348	1,200
Spirits of turpentine ..... bbls	.....	.....	4,400	11,434	13,898
Rosin ..... do	.....	.....	17,000	49,293	54,681
Cotton ..... bales	.....	3,000	.....	1,573	2,786
Merchandise ..... tons	.....	.....	.....	1,660	.....
Merchandise, cotton, guano, etc	.....	7,014	6,000	.....	3,855
Wool ..... bales	.....	.....	.....	.....	25
Hides ..... do	.....	.....	.....	.....	19
Sirup ..... bbls	.....	.....	.....	.....	51

This table shows that notwithstanding the bad condition of the river the commerce has been increasing, and very rapidly, too.

Not being able to get any later information than 1880, I have taken from the United States census of that year the amount of produce, and, after making an allowance of 30 or 44 per cent. for increase and a liberal allowance for home consumption, put down in the following table the amounts opposite each county as being the probable amounts that would be exported were the river put in a navigable condition. I also assume that nine-tenths of the products of Montgomery County will be shipped by river; three-quarters of Laurens; one-third of Johnson; one-fifth of Wilkinson; one-sixth of Washington, and one-quarter of Baldwin, and that the balance will go by rail.

Counties.	Cotton.	Potatoes.	Wool.	Corn.	Oats.
	Bales.	*Bush.*	*Pounds.*	*Bush.*	*Bush.*
Montgomery	1,000	30,000	45,000	70,000	10,000
Laurens	7,670	25,000	30,000	120,000	5,000
Johnson	1,500	5,000	6,000	20,000	1,000
Wilkinson	2,000	5,000	1,000	50,000	8,000
Washington	6,000	10,000	2,000	50,000	8,000
Baldwin	3,000	1,000	1,000	20,000	.....
Total	21,170	76,000	85,000	330,000	29,000
Total tons	5,200	2,200	45	10,000	440

	Tons.
Total of exports of produce	17,885
Guano	8,000
Naval stores	16,000
Merchandise, provisions, etc	5,000
Total commerce	46,885

It is quite likely that the river would draw a larger proportion of cotton than of other produce. If it is supposed that the river will draw all of the cotton, then the above estimate should be increased to 55,685 tons.

On the supposition that the river will draw all commerce this amount should be 121,165 tons.

The annual output of timber is variously estimated at from 20,000,000 to 30,000,000 feet. This, with the other commerce of the river, if taken by train would make one continuous train 60 miles long, or would require two freight trains per day to transact the necessary business.

It is a general truth that where steam-boats and railroads compete for the patronage of any section of the country the steam-boats get the greater part of the heavy and bulky freights and such as are not likely to be damaged by exposure to the weather, and that the railroads get the dry goods, most of the groceries and perishable goods, and also small and expensive goods. If there is a point or points on the river where large wholesale business houses are established the problem becomes a different one. Their shipments being so very large they can make arrangements for some time ahead for their freights and can provide for the protection of goods that will not stand exposure to the weather. They would therefore ship by boat a great many things that a small merchant would prefer to pay a little more for and get it sooner. No regular through business on long haul by boat would be permanent unless enough to keep a boat running all the year. It is my opinion that a regular line of steamers to Milledgeville will not pay. The place being too small to do a wholesale business the steamers would not secure anything more than the cotton business, and that would not amount to more than 15,000 bales. The local traffic that would be secured between the Central Railroad Bridge and Milledgeville would be very little, in all probability, as the railroad facilities on this section of the river are entirely sufficient for the wants of the people.

Leaving out the upper portion of the river to the Central Railroad Bridge the probable commerce will be as follows:

	Tons.		Tons.
Cotton	5,000	Guano	7,000
Potatoes	2,000	Naval stores	16,000
Wcol	40	Merchandise, etc	4,000
Corn	6,000		
Oats	225	Total	40,265

This is, in my opinion, a fair estimate of the actual amount of commerce that will be secured very soon after the river has been properly improved. It is also reasonably sure that this traffic will increase very rapidly for the same reason that a new railroad increases the commerce of any country and develops its resources. Assuming the average rate of freight to be $3 per ton, the value of the freight receipts that will most likely be secured on the opening of the river will be $120,795.

The following is an estimate of the population, land under cultivation, and value of all property in the counties named:

Counties.	Population.	Area of cultivated lands.	Value of all property.
		Acres.	*Dollars.*
Montgomery	6,730	25,000	1,126,000
Laurens	12,500	72,600	1,673,000
Johnson	6,000	40,200	943,000
Wilkinson	15,000	98,000	1,262,000
Washington	27,000	201,740	3,746,000
Baldwin	17,200	69,500	1,612,000
Total	84,430	507,040	10,362,000

Besides this the value of standing timber in Montgomery and Laurens Counties is $1,700,000.

There are transmitted with this report:

1. Map of Oconee River, in nine sheets.
2. Seven detailed surveys, in two sheets.
3. Profile of the river from the Forks to Skull's Shoals.
4. Sections for discharge measurements at Milledgeville, Dublin, and Bell's Ferry.
5. Plan of above sections showing location of soundings.
6. Graphical representation of all gauge readings.
7. Map of the State of Georgia showing the river valley.
8. Note-books used on the survey (five in number).
9. Sketch of the Central Railroad Bridge at Station Oconee.

Very respectfully, your obedient servant,

A. S. COOPER,
Assistant Engineer.

To O. M. CARTER,
First Lieutenant, Corps of Engineers, U. S. A.

O 12.

PRELIMINARY EXAMINATION OF THE OCMULGEE RIVER, GEORGIA.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., December 22, 1888.

GENERAL: I have the honor to submit the following report of a preliminary examination of the "Ocmulgee River, Georgia," in accordance with instructions contained in Department letter dated August 28, 1888.

The Ocmulgee River is formed by the confluence of the South and Yellow rivers, about 20 miles below Covington, and flows thence in a southeasterly direction about 350 miles, where it unites with the Oconee to form the Altamaha. From Covington to Macon the river is greatly obstructed by shoals, and its fall is so great that it can not be rendered navigable except by the establishment of a system of locks and dams, which the commerce, present and prospective, does not justify. Below Macon the slope is more gentle, and before the advent of railroads steamboats plied regularly between Macon and the coast when the river was at good boating stage, *i. e.*, about 7 feet above extreme low water. When the stage of water was too low for steam-boat navigation, poleboats were used. Below Macon the river runs through a low, heavily timbered country and is bordered by swamps from one-half to 3 miles wide. The soil is of alluvial deposit, overlying clay, with occasional outcrop of soft siliceous sandstone. It is easily eroded, and the channel, which is tortuous and shifting, is much obstructed by snags, overhanging trees, sand and gravel bars, and occasional reefs of rock.

Between 1817 and 1837 the State of Georgia expended about $60,000 in the improvement of the river, $10,000 of which were expended above Macon.

In 1852 an examination of the river was ordered by Congress, but no funds were appropriated for its improvement. In 1875 a survey of the river was made from Covington to Macon, and an examination from Macon to its mouth. The cost of obtaining a low-water channel, 60 feet wide and 4 feet deep, from Macon to the mouth was estimated at $56,240, and in 1876 Congress approved the project and appropriated money for carrying it into execution. Although this project, according to which all operations have since been carried on, considered Macon as the head of navigation, yet on account of the obstruction of the river by railroad bridges at various places between that point and Hawkinsville, 110 miles below, the latter has been taken as the actual head.

The original estimates of the cost of improvement were based on insufficient data, and in 1882 the estimates were revised and placed at $81,240. This proving insufficient, it was further increased in 1886 to $112,480. The appropriations made by Congress for this river up to the present date aggregate $79,500, and more than $65,000 have already been expended.

It is estimated that as a result of the work done freight rates have been reduced at least 40 per cent., steam-boats now run without accident, and at a stage of water some 3 feet lower than before the im-

provements were begun, and a section of country, rich in timber and well adapted to farming, has been opened up to settlement. In 1880 the counties bordering on the river, within the limits of the improvement, had an assessed valuation, real and personal, of $17,876,408.

It has been impossible to get satisfactory statistics of the commerce upon this river. Repeated and urgent applications for information of this description to more than a score of individuals and corporations doing business on the river, and presumably interested in its improvement, have failed to elicit a single reply.

The meager statistics given have been compiled with difficulty by Mr. F. C. Armstrong, the efficient assistant engineer in local charge of the improvements on the river, to whom I am indebted for much other information.

Commercial statistics.

Years.	Merchandise, naval stores, cotton, guano, etc.	Naval stores.	Spirits turpentine.	Rosin.	Merchandise.	Cotton.	Guano.	Timber and lumber.
	Tons.	*Barrels.*	*Barrels.*	*Barrels.*	*Tons.*	*Bales.*	*Sacks.*	*Feet.*
1879–'80	.....	2,259	.....	.....	100	1,338	8,228	.....
1883–'84	27,000	.....	.....	.....	.....	.....	.....	.....
1884–'85	.....	.....	6,800	28,000	3,200	.....	.....	.....
1887–'88	.....	.....	14,276	69,342	9,000	2,204	.....	40,000,000

The East Tennessee, Virginia and Georgia Railway has stations at Hawkinsville, the actual head of navigation, and Lumber City, 12 miles above the mouth of the river. The freight from the mouth of the river to Hollingsworth Ferry, a distance of 100 miles, goes principally to Lumber City, and that from Hollingsworth Ferry to Hawkinsville, a distance of 95 miles to Hawkinsville. Although the small boats here act as feeders to the railroad, the freight rates are affected by the larger boats running through to the coast to such an extent that it is cheaper for Lumber City merchants to haul their cotton one mile to White Bluff and ship by boat one-third of a mile to Ocmulgee Depot (the crossing of the Ocmulgee River by the East Tennessee, Virginia and Georgia Railway), and thence by the railway to its destination, than it is to ship by rail direct from the station at Lumber City, although the stations are only one mile apart and the same agent attends to the business of both.

For short local trips boats of small tonnage can be profitably operated, but for the economical carrying of freight to the coast larger boats are needed, and the obstructions in the river are at present such that boats of this class can not be run at extremely low water.

In the spring of 1888 the A., P. and L. Railway was completed to the Ocmulgee River, at Abbeville, 50 miles below Hawkinsville. This road, which passes for the most part through a virgin country and which has reduced the freights on competing lines about 40 per cent., depends for successful operation upon the Ocmulgee and Altamaha rivers for an outlet to the coast. This company now owns five steam-boats, four of which ply from Aebbville to the coast at Darien and Brunswick, and one from points on the Altamaha River to Savannah. In addition to

these, five other steamers ply on the river, three to Lumber City and two to Abbeville, from neighboring points.

From the foregoing I am of the opinion that the Ocmulgee River is worthy of improvement. Whether this improvement should extend beyond Hawkinsville can only be determined by a survey extending from Macon to the mouth of the river. The sum needed for this survey is $1,250.

I respectfully recommend that this sum may be allotted and the survey ordered.

Very respectfully, your obedient servant,

O. M. CARTER,
First Lieut., Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

SURVEY OF THE OCMULGEE RIVER, GEORGIA.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., February 5, 1890.

GENERAL: In accordance with the requirements of section 13 of the river and harbor act of August 11, 1888, and instructions from the Chief of Engineers, dated June 21, 1889, I have the honor to submit herewith my report upon the survey of the Ocmulgee River, Georgia, together with a project for its improvement and an estimate of the cost of the same.

A description of the river and such information as I was able to collect concerning its commercial importance are given in my report upon the preliminary examination, dated December 22, 1888, to which I respectfully refer. The survey of the river was made under my direction during September and October, 1889, by Mr. J. L. Van Ornum, surveyor, whose report is appended hereto. The basin of the Ocmulgee River above Macon comprises an area of 2,310 square miles. The river in this section is much obstructed by shoals, and its fall is so great that it can not be rendered navigable for steam-boats except by the establishment of a system of locks and dams which the commerce, present and prospective, does not justify. The area of the river basin below Macon is 3,910 square miles. The distance from Macon to the mouth of the river, measured along the channel, is 203 miles, and the low-water fall is 195.7 feet, an average of 11.67 inches per mile.

In the first 15 miles below Macon the average low-water slope is 9.63 inches per mile; for the next 41 miles it is 15.66 inches, the maximum being 32.4 inches. Over the rest of the river the slope is quite uniform, averaging 10.62 inches per mile. The discharge of the river at Macon varies from about 1,000 cubic feet per second at extreme low water of summer to about 55,000 cubic feet per second during high freshets. During extreme freshets the latter discharge may be exceeded. The mean velocities of discharge, as deduced from actual measurements at Macon, vary from 1.3 feet per second at 0.9 of a foot above summer low water to 3.155 feet per second at 10.1 feet above that stage. The mean velocity of discharge at Lumber City was found to be 1.273 feet per second at 0.48 of a foot above summer low water.

At Macon the river has been known to rise to 23.5 feet above summer low water; at Hawkinsville to 30.93 feet; at Abbeville to 19.27 feet, and at Lumber City to 19.84 feet above that level.

From Macon to Hawkinsville the low water width of the river averages about 150 feet; between Hawkinsville and Abbeville it is more nearly straight and wider; between Abbeville and the mouth of the river its low water width averages from 200 to 300 feet.

Omitting the bridges, the principal obstructions to the navigation of the Ocmulgee River are over-hanging trees, snags and logs, ledges of rock and gravel, and sand-bars. Upon the upper portion of the river shoals of rock and gravel predominate, while the principal shoals in the lower reaches of the river are composed of sand.

The shoals are troublesome only at low water, while the obstructions caused by overhanging trees, snags, and logs cause trouble at all stages of the river.

That portion of the river between Macon and Hawkinsville is greatly obstructed. Between Hawkinsville and The Forks the river banks have been rreed from the most troublesome overhanging trees, and the worst snags and logs have been removed from the river between The Forks and Abbeville.

The ordinary discharge of the Ocmulgee River is sufficient, if properly directed and confined, to afford a navigable channel 3 feet deep at summer low water between Macon and the river's mouth. This depth is sufficient for the present and prospective commercial demands.

The survey of the river was made when the water was but little above the low stage of summer, and the general maps show the character and extent of the obstructions encountered. To cover such a length of river in so short a time necessarily forbade a detailed examination of all of the places where obstructions to navigation are found, and in making estimates of the cost of improvement the information obtained during the survey has been supplemented by that obtained from previous personal examinations as well as from other reliable sources.

The shoals encountered in ascending the river are given in detail in Mr. Van Ornum's report. Those places where works of improvement are now recommended are given in the following table:

Number of obstruction.	Distance above the forks.	Name.	Character.	Recommendations.	Estimated cost of improvement.
	Miles.				
1	4.5	Cut-off No. 1	Cut-off	Should be closed	$300.00
2	5.5	Tillman's Bar	Sand-bar	To build spur-dikes of piles and brush for the contraction of the low-water channel, and to protect the concave bank with brush fascines and rip-rap stone.	4,000.00
3	9.0	Quinn's Shoals	Rock ledge	To remove about 250 cubic yards of rock from right-hand side of river channel.	1,250.00
4	13.1	Shoal No. 1	Sand-bar	To construct spur-dikes for contracting low-water channel.	1,500.00
5	13.6	Hubbard' Shoals.	Rock ledge	To remove isolated points and loose rock obstructing low-water navigation.	500.00
6	15.0	McRea's Bar	Sand-bar	To construct spur-dikes for the contraction of the low-water channel, and to protect the concave bank with brush fascines and rip-rap stone.	3,000.00
7	19.6	Cut-off No. 2	Cut-off	Should be closed	250.00
8	22.0	Shoal No. 2	Rock ledges	To remove rock dangerous to low-water navigation.	500.00
9	24.5	Cut-off No. 3	Cut-off	Should be closed	300.00
10	25.7	Cut-off No. 4	....do	....do	300.00
11	35.3	Cut-off No. 5	....do	....do	600.00
12	39.8	Little River	....do	....do	200.00
13	40.3	Cut-off No. 6	....do	....do	300.00
14	42.6	Cut-off No. 7	....do	....do	200.00
15	53.2	Shoal No. 3	Sand-bar	To construct spur-dikes for contraction of low-water channel.	1,500.00
16	60.3	Fodder Stack Cut	Cut-off	Should be closed	750.00
17	69.6	Cut-off No. 8	....do	Cut should be closed and the sharp turn at Tiger Leap, just below, eased off.	1,000.00
18	72.8	House Creek Suck.	....do	Should be closed	750.00
19	82.2	Crawford's Suck	....do	....do	600.00
20	84.6 to 86.2	Henly's Points	Projecting points.	A portion of the upper projecting point should be removed and the channel rendered easy for steamboats.	1,000.00
21	85.1 and 85.4	Cut-offs Nos. 9 and 10.	Cut-offs	Should be closed	500.00
22	91.7 to 92.3	Stadem's Shoals	Rock ledges	A channel 60 feet in width and 3 feet deep at summer low water should be cut through all of the shoals in this locality. The water was high when the survey of these shoals was made and some of the ledges were missed.	6,000.00

Number of obstruction.	Distance above the forks.	Name.	Character.	Recommendations.	Estimated cost of improvement.
	Miles.				
23	95.4	Cut-off No. 11	Cut-off	Should be closed	$300.00
24	99.2	Miller's Shoal	Rock ledge	A small amount of excavation needed.	750.00
25	99.8	Cut-off No. 12	Cut-off	Should be closed	100.00
26	100.5	McGee's fractions	Rock ledge	A small amount of excavation necessary.	750.00
27	100.6	Cut-off No. 13	Cut-off	Should be closed	300.00
28	101.0	Cut-off No. 14	do	do	200.00
29	102.3	Cowface bar	Sand-bar	Low-water channel should be contracted by spur-dikes.	1,500.00
30	102.8	Cut-off No. 15	Cut-off	Should be closed	200.00
31	108.7	Daniel's Shoal	Rock ledge	Some rock should be excavated from point of ledge.	750.00
32	110.7	Davis' or Bluff Shoal.	Rock ledges	Channel is crooked and dangerous at low water; needs widening.	2,500.00
33	113.6	Indian Bluff Shoals	do	Some excavation necessary to improve safety of navigation.	750.00
34	118.1	Cut-off No. 16	Cut-off	Should be closed	200.00
35	120.9	Bluff Creek Shoals	Rock ledges	Some excavation necessary to improve ease and safety of navigation.	750.00
36	123.4	Shoal No. 4	Rock ledge	do	750.00
37	126.7	Seven Sycamore Shoals.	Rock ledges and bowlders.	The channel should be widened, deepened, and straightened, and isolated bowlders removed.	5,000.00
38	130.1	Grady's Shoals	do	do	1,000.00
39	133.3	Hawkinsville Town Shoals.	Rock ledge	The channel needs widening; all isolated bowlders should be removed. The excavated material should be placed in a training-wall to throw water into the excavated channel.	1,500.00
40	133.9	Buttermilk Shoals.	Rock ledges	A channel 60 feet wide and 3 feet deep at summer water should be made through the ledge, and all isolated bowlders obstructing navigation should be removed. The excavated material should be used in constructing training dams.	10,500.00
41	134.9	Tan-yard Shoal	do	The end of the ledge projecting into the channel as well as isolated bowlders should be removed, the excavated material being utilized in constructing training dams.	7,500.00
42	135.4	Taylor's Bluff Shoals.	do	A channel 30 feet wide and 3 feet deep at summer low water should be cut through the shoals; the excavated material placed in training dams. All isolated bowlders should also be removed.	15,000.00
43	137.9	Collier's Bluff Shoals.	do	The end of the ledge projecting into the channel should be cut off and all isolated bowlders removed, the excavated material being placed in training dams.	2,000.00
44	142.1	Shoal No. 5	Sand-bar	The low-water channel can be improved by closing the channel on the western side of the island.	1,000.00
45	143.6	Cypress Point	Projecting point	Should be partially cut off to render navigation easy.	500.00
46	147.0		Projecting points.	The incipient cut should be closed and the points partially cut off to render it easier for steam-boat navigation.	750.00
47	155.5	Long Stretch Bar	Sand-bar	The low-water channel should be contracted by spur-dikes.	1,500.00
48	159.0	Cut-off No. 17	Cut-offs	Both should be closed	350.00
49	160.4		Projecting points.	Should be closed and partially cut away.	500.00
50	160.7	Cut-off No. 18	Cut-offs	Should be closed	250.00
51	162.9	Cut-off No. 19	do	do	250.00
52	163.1	Cut-off No. 20	do	do	250.00
53	165.3	Cut-off No. 21	do	do	200.00
54	173.8	Indian Cut-off	do	do	200.00
55	177.2	Cut-off No. 22	do	do	200.00

Number of obstruction.	Distance above the forks.	Name.	Character.	Recommendations.	Estimated cost of improvement.
	Miles.				
56	178.4	Cut-off No. 23	Cut-offs	Should be closed	$100.00
57	183.9	Cut-off No. 24	do	do	100.00
58	188.8	Tobesofkee Cut-off.	do	do	500.00
59	196.7	Cherry's Bl. Bar	Sand-bar	Low water channel should be contracted by spur-dikes.	1,500.00
60	197.6	Shoal No. 6	do	do	1,500.00
61	198.8	Shoal No. 7	do	do	1,500.00
62	199.5	Buzzard's Bar	do	do	2,100.00
63	200.2	Gravelly Bar.	Sand and gravel bar.	do	3,000.00
64	202.0	Macon Bar	Sand-bar	do	3,000.00
					96,850.00
		For improvement of shoals possibly developed by changes in the régime of the river, due to alterations of the river slope			20,000.00
		Removal of 10,000 overhanging trees; 6,000 above Hawkinsville and 4,000 below, at 50 cents each			5,000.00
		Removal of 15,000 snags, one-half above and one-half below Hawkinsville, at $3 each			45,000.00
		Working plant			15,000.00
		Total			131,850.00
		Engineering and contingencies, 15 per cent			27,277.75
		Aggregate			209,127.75

The above estimates are based upon the assumption that at least $50,000 will be annually available for the work. Should the appropriations be small in amount or irregularly made, the cost of improvement will be greatly increased.

Rock shoals once properly removed will not reappear. With this exception no permanent improvement of the Ocmulgee River can ever be effected at any reasonable cost. The soil composing the bed and banks of the river is so easily eroded that new obstructions, caused by logs, snags, and overhanging trees, form during every high-water season, and as the regimen of the river changes new shoals of rock, gravel, or sand are developed and the position and extent of sand-bars now in existence but not at present needing improvement will be modified. To what extent this change will take place can not be foreseen, and no accurate estimate for the improvement and maintenance of the river can now be made. The estimate submitted herewith is for the removal of the existing obstructions to navigation. When new obstructions form, estimates for their removal can then be made.

The river once cleared of the most troublesome and dangerous logs and snags, will require a snag-boat for perhaps only two or three months of each year, making the probable cost of maintenance of the completed work from $3,000 to $5,000 annually.

The value of the present annual commerce, as will be seen by referring to the very full and interesting report of Mr. Van Ornum, is about $3,000,000.

The population of the Ocmulgee River counties at and below Macon is estimated at 175,000, and the total value of personal and real property at about $26,000,000. The value of the timber products in this region for the year 1889 amounted to about $2,500,000; of the manufactured products to about $5,000,000, and of the farm products to over $6,000,000.

The area of the section of country naturally tributary to the Ocmulgee River is about 2,400 square miles. The value of the property in this area is more than one-half of that in all of the Ocmulgee River counties referred to; it contains a good part of their manufactures and a large proportion of the valuable timber.

It is estimated by the Macon Board of Trade that the saving on incoming and outgoing freights at Macon, were the river in good navigable condition from Macon to the mouth, would amount to more than half a million dollars annually. This is perhaps an extravagant estimate, but that an improved river would have a powerful effect in controlling and regulating freight rates in the river basin there can be no doubt.

It is estimated that, as a result of the work already done between Hawkinsville and the mouth of the river, freight rates have been reduced at least 40 per cent. Steam-boats now run without accident and at a stage of water 3 feet lower than before the works of improvement were inaugurated. The further improvement of the river would render accessible a very large and valuable supply of various timbers lying between Macon and Hawkinsville; would enable the planters in the river basin to more economically transport their bulkier products to market, and would bring about a reduction of freight rates over a much larger territory than that affected by past work, and would aid in opening up sections of country which, commercially, do not now exist.

In view of all of the facts collected, the Ocmulgee River is considered worthy of improvement from Macon to its mouth, with a view to obtaining a navigable channel 3 feet in depth at ordinary summer low water.

The cost of such an improvement is estimated, in round numbers, at $210,000.

The sum of $50,000 can be advantageously and economically expended during the present fiscal year.

The following papers and maps accompanying this report:

1. Report of Mr. J. L. Van Ornum, surveyor.
* 2. Index map of Ocmulgee River from Macon to the mouth (in 2 sheets).
* 3. General map of Ocmulgee River from Macon to the mouth (in 11 sheets).
* 4. Profile of Ocmulgee River from Macon to the mouth.
* 5. Map of detailed surveys of Ocmulgee River from Macon to the mouth (in 4 sheets).

Respectfully submitted.

O. M. CARTER,
First Lieut., Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. J. L. VAN ORNUM, SURVEYOR.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., January 30, 1890.

SIR: I have the honor to submit the following report of a compass and stadia survey of the Ocmulgee River from Macon to the river's mouth made pursuant to the following instructions:

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., August 13, 1889.

Mr. J. L. VAN ORNUM,
Surveyor, Savannah, Ga.:

SIR: As soon as the stage of water is suitable you will proceed to make a compass and stadia survey of the Ocmulgee River from Macon to the river's mouth.

You will note the height, character, and condition of the river banks, the size and variety of trees and brush, the length and depth of pools and shoals, the variations

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* Omitted; printed in House Ex. Doc. No. 215, Fifty-first Congress, first session.

in water level at different points, the nature of the river bottom, and the location, nature, and magnitudes of existing obstructions of navigation with a view to determining the methods and probable cost of removing them so as to secure a depth of 3 feet at summer low water.

You will also collect statistics, as much in detail as possible, concerning the character and amount of commerce and navigation, prospective as well as present, interested in the proposed improvement.

The high and low water slopes of the river will be determined instrumentally, permanent beach-marks being established at intervals along the line. Near Macon, Hawkinsville, Abbeville, and Lumber City cross-sections of the river will be carefully determined for use in discharge measurements. When practicable these sections will be continued to the high-water mark by leveling and permanent bench-marks established. The velocity measurements will be made by means of loaded rods, surface or double floats, and the low, ordinary, and high water discharges obtained. Permanent gauge staves will be established at Macon, Abbeville, and Lumber City, and intelligent gauge readers employed at a compensation not to exceed $7.50 per month. The gauges will be connected with at least two good prominent and permanent bench-marks. Detailed descriptions (with sketches) will be given of all bridges crossing the river. The map of the survey, which will be plotted on a scale of 1-.9600, should show the general contour of the river banks, the location of the navigable channel, with low-water depths, the location of cut-offs, sand-bars, etc. At shoals where rock excavation or works of contraction may be required detailed surveys on a scale of 1-.1200 will be made, and the river slope from the pool above to the pool below carefully determined. The profile of the river will be plotted on a horizontal scale of about 2 miles to an inch and a vertical scale of about 30 feet to an inch.

In view of the verbal orders given to you no further instructions are considered necessary.

You are authorized to employ such assistance and means of transportation as may be required for a vigorous prosecution of the work. * * * Your field-maps will be kept plotted to date and the usual tri-monthly report of operations submitted to this office. As soon as the field-work of the survey is completed, all employés will be discharged, and you will return to this office.

Very respectfully, your obedient servant,

O. M. CARTER,
First Lieut., Corps of Engineers, U. S. A.

That part of the instructions providing that the profile should be plotted on a vertical scale of about 30 feet to an inch was modified orally by substituting 12 feet for the 30 feet given.

A high stage of water prevented a start during August; but during this time was built at Macon a house-flat 40 feet long and 10 feet wide, having about 10 inches draught, the house containing three rooms, each 10 feet square and 7 feet high. The cost of the house-flat, not including the time of the engineers, was about $160. A row-boat and a bateau were used for the actual work of the survey.

The survey was begun on September 7, 1889, at Macon and the Forks was reached on October 16, 1889. Mr. A. S. Cooper, assistant engineer, accompanied the survey from Macon to Hawkinsville. The total length of river from Macon to the Forks is 203 miles; total fall 195.7 feet; 22 detailed surveys were made; 3 gaugings for discharge, 3 cross-sections of river valley and 9 cross-sections of the river were taken; and the 6 bridges crossing the river were sketched and measured.

The party consisted of two boatmen, two deck-hands, cook, leadsman, rodman, and myself.

In this survey the general method followed was for the transitman from his position to take an observation for bearing, distance, and elevation back to the rodman's station. Then the rodman would move ahead to an advantageous position, when an observation would be taken to the rodman's new station for bearing, distance, and elevation from the same transit station. Then the transit man would move ahead of the rodman and the process be repeated. Usually the turning points were at the water's surface, giving at once the elevation of the water at each turning point; if they were not so, measurements were taken to the surface of the water.

It was the intention to limit the length of sights to 2,000 feet on account of the levels taken, and rarely did they exceed that distance. The correction for curvature and refraction for 2,000 feet is less than 0.1 foot, and so the liability to error in level small; but beyond that distance the correction increases rapidly and so increases rapidly the liability of error in the level line. Of course each reading was corrected for curvature and refraction to the nearest hundredth, the corrections as applied being given in table Appendix A. The transit used was the Brandis No. 1053.

When moving from one transit point to the next the transmitman recorded the position of snags and trees in the river and the channel soundings taken, and

sketched in the river banks and channel, bars, bluffs, cut-offs, creeks, landings, etc., and whenever the sketch would not well indicate the approximate position of a prominent feature of the river an observation to it was taken from a transit station. Flood heights were recorded wherever they could be obtained. Bench-marks were established at detailed surveys, gauges, and cross-sections, and at intervals along the river. A gauge of the river was always kept at the flat when not in motion, to record the rise or fall of the river. When in motion, the house-flat probably floated about as fast as the rise or fall in water advanced, so that the actual rise or fall of the river should be closely that indicated by the house-flat gauge; and such was usually the fact, as shown by comparisons with the fixed gauge-stave readings at Macon, Abbeville, and Lumber City. Gauge readings have been taken at all three places just mentioned since August, 1889.

The river bottom is, in general, a quite firm sand, sometimes rock (which in the upper river, in the vicinity of Hawkinsville, is a hard flinty rock, and in the lower river a soft limestone), and occasionally hard clay.

The river banks partake of the usual characteristics of an alluvial river bank, being a yellowish or dark earth, rather easily eroded. Low bluffs that touch the river often contain sand or gravel and the high bluffs in these lower portions often contain a rock which is firm or friable, as the bluff is situated in the upper or lower river valley.

The river valley is from 2 to 5 miles wide, inclosed by highlands from 40 to 80 feet high. The higher bluffs of the river are usually points where the river flows close to these highlands. The changes of conditions of the river that occur in the course of time are sometimes quite apparent in the varying position of some sand-bar. The portion of the river between Macon and the railroad bridge, a mile below, which in 1875 had a depth of about three feet, now has a depth of five feet; these bars seem to have been transported down-stream, reappearing now from 1 to 7 miles below Macon.

Cut-offs often form across low necks of land where there is a considerable fall, and sometimes endanger navigation by diverting a part of the river's flow. When the river is high the flow through these cut-offs is great, and they seem to be a cause for concern to the interests of navigation; but in fact there are comparitively few cut-offs which are not dry at summer low water, natural causes, chief among which are the extensive and tenacious growths of cypress trees and knees, fortunately making erosive action outside of the river banks both slow and difficult.

The trees of the Ocmulgee valley, between Macon and Hawkinsville, are largely hard woods, the most valuable timber being white oak, ash, hickory, beech, maple, and elm. Black gum, sweet gum, sycamore, cottonwood, water oak, poplar, cypress, and willows are also found, and the pine occurs on the higher lands; great tangled thickets of swamp cane and brush are characteristic of this portion of the valley.

Below Hawkinsville the pine becomes the valuable timber of the valley, occurring on the bluffs. The hard woods just mentioned, though in less quantity, are found on the moderate river banks, frequently with bushes and brush; cypress characterize the low banks and willows the points.

The head waters of the streams forming the Ocmulgee River are in the hills of North Georgia, and from its head to Macon the river has a high rate of fall, presenting characteristics that render navigation impracticable. (See report of survey of Ocmulgee River above Macon in 1875, etc.—Report of the Chief of Engineers.) This water-shed of the upper Ocmulgee comprises an area of about 2,310 square miles, and at low stages of water in the navigable portions of the river it furnishes a good proportion and relatively reliable source of the river's flow. A table of rainfall at Macon from July 1, 1878, to July 1, 1889, is given in appendix B.

From Macon, the natural head of navigation of the Ocmulgee River, to the Forks, the character of the river is entirely different, the rate of fall averages not one foot per mile, and its tributary area of about 3,910 square miles, while supplying immense quantities of flood-water, furnishes a relatively small proportion of the discharge of the river at summer low water.

From Macon (203 miles from the Forks) to Hawkinsville (133 miles) the river is now not navigable, the Covington and Macon Railroad bridge, 1 mile below Macon, the East Tennessee, Virginia and Georgia Railroad bridges, one 10 miles below Macon and the other at Hawkinsville, and the highway bridge at Hawkinsville completely preventing navigation. This portion of the river will average perhaps 150 feet wide, being in general narrow and deep; the shoals and bars are comparatively few, but the succession of shoals near Hawkinsville are the worst on the river as far as the survey extended.

As the river here has not been used for over twenty years, logs, snags, and trees have accumulated till now they form extensive obstructions, though easily and comparatively quickly removable. The number of trees, snags, and logs that need removal through this distance of 70 miles is about 400. At the usual stage of water this portion of the river would be navigable were the trees and snags removed and

the bridges remodeled; but at low stages there are three bars within five miles of Macon and five shoals all within five miles of Hawkinsville that would make navigation impossible; and there are three dangerous points that require improvement, as they necessitate sharper turns than steam-boats going down-stream could make. There are four other bars within seven miles of Macon that might give trouble but it is believed that when this portion of the river is cleared of trees and navigation is begun they will offer no obstructions; these with other obstructions of the river will be noted in detail in the table of obstructions below.

From Hawkinsville (133 miles), the present head of navigation, to Abbeville (Savannah, Americus and Montgomery Railroad wharf, 93.8 miles), the river is straighter and wider and is, in general, good. Only one shoal, Seven Sycamores Shoal (126.7 miles), demands especial mention and early attention. In this portion of the river this shoal is always the first to give trouble, and is the one which first stops navigation at very low stages of the river. One hundred and five trees, snags, and logs were observed, probably half of which should receive early attention, though the removal of those just above Cow Face Bar (102.3 miles) only is urgent.

From Abbeville (93.8 miles) to Lumber City (Ocmulgee Depot, 11.4 miles) and to the Forks the river averages from 200 to 280 feet wide, and is shallower. In this portion of the river about 250 logs, trees, and snags were found, the larger portion of which were above Lampkin's Old Field (61.5 miles), where I passed the U. S. snag-boat *Ocmulgee*. Stadem's Shoals (91.7 and 92.3 miles) are the only serious shoals in this portion of the river requiring early improvement. River pilots and others agree in calling Stadem's Shoals serious obstructions and dangerous at low stages of the river. Their reputation is fully as bad as that of Seven Sycamores Shoals above. The least channel depths as found in the survey indicate a safe margin for the passage of boats over these shoals at summer low water, but this survey was made when the river was here over 6 feet above summer low water—overflowing its banks—and the current was very swift. It is probably the case that, while the result of the surveys indicates the general river bottom, there are scattering lumps of rock which escape the detection of the sounding-lead, and which occasion the difficulties and dangers to navigation at low stages of the river. The location of these dangerous points of rock and of other ledges near that may trouble, requires a special survey of these shoals at low water. From this point to McRae's Landing (15 miles) the river is good.

The lower 15 miles of the Ocmulgee is the shoalest portion of the river as far as it is now navigated, the crossings where the channel changes from one bank to the other often in succession offering only from 3 to 4 feet of water at summer low water. Tillman's Bar (5.4 miles) requires especial and early attention. The river here widens to between 500 and 600 feet for a distance of one-quarter of a mile, and has always given trouble at low stages of water. In February and March, 1883, there were constructed two pile jetties extending outward from the left (bight) side of the river, the upper jetty being near the upper end of the bar and extending 140 feet from the bank, and the lower jetty being about midway of the bar and extending outward 250 feet from the bank. These jetties have had the effect of deepening the water opposite them to about 4 feet at summer low water, and have thrown the shoalest portion of the bar down-stream to the lower end of the bar and almost to deep water. The eroding and caving of the right bank has also increased the shoaling of the river. Additional improvement is now required at this lower and shoaler portion of the bar.

The following is a table in detail of all natural obstructions to navigation in the Ocmulgee River, not including trees and snags and including cut-offs, that endanger navigation by probability of enlargement, the survey being based on the project to secure a channel depth of 3 feet at summer low water.

Number.*	Distance from forks.	Name.	Nature of obstruction.	Length.	Fall from pool to pool.	Channel depth of least cross-section.†	Width of river.	Description.	Remarks.
	Miles.			*Feet.*	*Feet.*	*Feet.*	*Feet.*		
V	1.8	Oaky Bluff Bar...	Sand-bar.....	700	0.16	3.0	450	Channel close to right bank; bar on left	
U	2.2	.....	....do	400	0.10	3.3	400	Shoaling caused by trees and snags; channel at left bank.	One tree and two snags should be removed.
3	4.5	.....	Cut-off	.....	.....	.....	.....	Thirty feet wide; little flow at summer low water.	Should be closed.
T	5.5	Tillman's Bar	Sand-bar.....	1,500	0.32	2.5	500 to 600	General description given above. Good channel at right bank until lower end of bar is reached, when the troublesome portion of the bar is encountered in crossing from right bank to deep water in bight at the left bank.	Works of contraction are required at lower end of bar. About 500 feet of works necessary for deflecting jetty at right bank, and for shore protection opposite.
S	9.0	Quinn's Shoal	Rock shoal	200	0.32	5.0	200	Shoal projects from right (channel) side one-third across river, just below sharp turn around point in left bank. Good channel by shoal at left bank, but hard turn for boats.	
R	13.1	.....	Sand-bar.....	400	0.21	3.2	300	Shallow crossing from left to right side of river.	
Q	13.6	Hubbard's Shoal..	Rock shoal	300	0.52	4.0	320	Rock shoal in middle of river. A channel was cut through the right bank to the right of shoal in 1881, giving new, good channel and little trouble.	
O	15.0	Bar at McRae's Landing.	Sand-bar.....	800	0.23	3.0	450	Channel along right bank to lower end of bar, where it crosses to deep water in the bight at left bank.	
9	19.6	.....	Cut-off.....	.....	.....	.....	.....	Twenty-five feet wide; not deep.....	Should be closed.
10	21.9 and 22.1	.....	Rock shoals.....	.....	.....	6.0	.....	Rocks on right (channel) side river. Good channel at left side. Current swift.	Require care.
11	24.5	.....	Cut-off.....	.....	.....	.....	.....	Thirty feet wide; some cypress growing in its course.	Should be closed.
12	25.7	.....	....do	.....	.....	.....	.....	Two cut-offs 10 and 20 feet wide; not deep...	Do.
13	35.3	.....	....do	.....	.....	.....	.....	Two cut-offs. The upper one is bad; it is 60 feet wide and discharges a considerable amount of water.	Do.
14	39.8	Little River	....do	.....	.....	.....	.....	Twenty feet wide; rather bad	Do.
15	40.3	.....	....do	.....	.....	.....	.....	Thirty feet wide	Do.
16	42.6	.....	....do	.....	.....	.....	.....	Twenty feet wide; 500 feet long; little fall .	Do.

17	60.3	Fodder Stack Cut.	... do	.....	.....	.....	.....	Bad cut-off, about 70 feet wide and 8 feet deep; diverts a considerable quantity of water.	Do.
18	69.6	.....	....do	800	0.30 (about)	.....	.....	Cut-off 50 feet wide and about 5 feet deep at summer low water; some trees at upper end. This cut-off extends in the natural direction of the river, the river passing to right of cut-off and making sharp and hard turn for steam-boats at Tiger Leap, just below.	Should be opened to straighten the channel and cut off the hard Tiger Leap turn; involving removal of about 8,000 cubic yards of earth and 70 trees averaging 1 foot in diameter.
19	72.8	House Creek Suck.	....do	400	.....	.....	.....	Rather bad cut-off, 100 feet wide; some trees growing in it.	Should be closed.
20	82.2	Crawford's Suck..	....do	.....	.....	.....	.....	Sixty feet wide; deflects considerable water; danger of enlarging.	Do.
21	84.6 to 86.2	Five Henley's Points.	Projecting points.	.....	.....	.....	.....	Four of these turns not very hard, but the upper one (86.2) is especially bad, necessitating a turn of 180 degrees inside of about 400 feet width; average fall per mile, 0.4 foot.	A cut should be opened from 86.20 miles to 85.25 miles, thus cutting off the worst three points; this cut would be 500 feet long through 6-foot bank, and requires removal of about 14,000 cubic yards of earth.
22	85.1 and 85.4	.....	Cut-off.....	.....	.....	.....	.....	Two cut-offs, 30 and 20 feet wide; not very bad.	Should be closed.
M	91.7	Stadem's Lower Shoal.	Rock shoal	500	(‡)	3.8	250	Troublesome and dangerous shoal extending across river; the channel across the shoal is near the left side of river, crossing to right side below. Isolated rocks probably occasion the trouble. Exact data should be obtained by re-survey at low water.	Scattering lumps of rock should be removed from channel; about 80 cubic yards rock. §
L	92.3	Stadem's Upper Shoal.	....do	400	(‡)	3.9	220	Channel crosses from right to left bank just above shoal; same general characteristics as "M."	Projecting lumps of rock should be removed. Probably about 50 yards. §
25	94.5	.....	Projecting point..	.....	.....	.....	.....	Hard turn for boat, but can be worked	
26	95.4	.....	Cut-off.....	.....	.....	.....	.....	About 30 feet wide; not very bad.....	Should be closed.
27	99.8	.....	....do	.....	.....	.....	.....	Ten feet wide; 600 feet long; considerable fall.	Do.
28	100.6	.....	....do	.....	.....	.....	.....	Cut-off about 30 feet wide, and lake; considerable water deflected.	Do.
29	101.0	.....	....do	.....	.....	.....	.....	Twenty feet wide and 250 feet long.....	Should be closed, as water deflected is needed to prevent encroachment of bars at sharp bend below, which makes hard turn for boats.
K	102.3	Cow-Face Bar	Sand-bar.....	800	0.10	3.0	200	Bar on right side of river extending nearly to left side; good channel close to left bank, but filled with trees and snags.	Six trees and 10 snags should be removed.
31	102.8	.....	Cut-off.....	.....	.....	.....	.....	Twenty feet wide and probably 4 feet deep at summer low water.	Should be closed. The considerable amount of water deflected is needed for the channel at Cow-Face Bar and Cow-Face Round (which makes hard turn) just below.

*Letters refer to detailed surveys.
†Referred to summer low water.
‡River high; fall could not be measured.
§All yardage of work in this report is estimated *in situ*.

Number.*	Distance from forks.	Name.	Nature of obstruction.	Length.	Fall from pool to pool.	Channel depth of least cross-section.†	Width of river.	Description.	Remarks.
	Miles.			*Feet.*	*Feet.*	*Feet.*	*Feet.*		
32	108.7	Daniel's Shoal....	Rock shoal	.....	.....	11.1	180	Shoal at left (channel) side extending half across river just below a point on right; good channel close to right bank.	Sharp turn; requires care.
33	110.7	Davis' or White Bluff Shoals.	Rock shoals	.....	.....	5.0	200	Shoal at right bank extending half across river, and another shoal just below extending from left bank two-thirds across, leaving channel of perhaps 70 feet, necessitating sharp turn.	Channel should be straightened by the removal of the outer 80 feet of the lower (left hand) shoal—about 150 cubic yards of rock.
34	113.6	Indian Bluff Shoal.	Rock shoal	.....	.....	6.0	220	Shoal extending from right (channel) side half across river, and just below point on left; good channel at left bank.	Not dangerous; care necessary.
35	118.1	.....	Cut-off.....	.....	.....	.....	.....	Twenty feet wide; considerable fall.....	Should be closed.
36	120.9	Bluff Creek Shoal.	Rock shoal	.....	.....	6.0	200	Extends from right (channel) side of river about two-thirds across; good channel close to left bank.	Requires care.
37	123.4	.....	....do	.....	.....	6.0	225	Ledge of rock extends from right bank, just below point on right side river, about one-half across. Another ledge just below extends from left bank about half across, leaving channel of perhaps 150 feet.	Sharp turn; requires care.
J	126.7	Seven Sycamores' Shoal.	....do	350	0.18	3.0	180	Shoal entirely across river; channel near right side; this shoal shows a general bottom level of sufficient depth of channel, but the obstructions and dangers to navigation are caused by scattering lumps of hard rock.	Should be improved by removal of these projecting points of rocks from 80-foot channel. About 50 cubic yards rock to be removed.
I	130.1	Grady's Shoal	Rock shoals	250	0.34	3.7	250	Channel at left bank; at this shoal an artificial barrier of stone V-shaped and pointing up river, and about 1 foot below summer low water, has been thrown up, the right arm reaching close to right bank and the left arm to within about 50 feet of left bank of river. Through this gap the channel passes. Projecting points of rock complained of.	Should be improved by the removal of these isolated lumps of flint rock. About 30 cubic yards of rock to be removed.
40	131.5	Gilstrap's Shoal ..	Rock shoal	.....	.....	5.0	170	Ledge projecting from right (channel) side of river nearly two-thirds across. Good channel at left side.	

H	133.3	Hawkinsville Town Shoal.	... do	25	0.23	2.8	240	Ledge of hard, flinty rock about 2 feet below summer low water, projects from right bank, trending somewhat down-stream, about one-half across river. Opposite this a ledge projects from left bank, trending up-stream about one-fourth across. Channel of 60 feet width between the ledges.	Should be improved by removal of scattering points of rock from the channel—about 50 cubic yards.
G	133.9	Buttermilk Shoal .	....do	1,100	1.11	2.0	200 to 300	Long shoal of hard rock entirely across river; channel at upper end crosses quickly from right to left side of river, and continues on this side to lower end of shoal. At the worst portion an artificial barrier of stone has been built about to summer low-water surface, extending from near right bank, with down-stream trend to within 60 feet of left bank; thence down-stream parallel to bank for 130 feet. The channel runs through this gap. One hundred feet below the end of this barrier a point of rock projects from left bank 20 feet into the channel.	Should be improved by the removal of isolated lumps from the channel above the barrier and through the gap, by the removal of the jutting point of rock, and by the excavation of a 60-foot channel for 300 feet below the end of the barrier, using removed rock to extend barrier down-stream. About 295 cubic yards of rock to be removed.
F	134.9	Tan-yard Shoal...	....do	700	0.41	2.5	270	Channel follows left bank till the worst portion of shoal is passed, when it crosses quickly to right bank. At the worst portion of the shoal a ledge reaches to within 1 foot of summer low-water surface, extending from right bank to within 60 feet of left bank, the channel passing through this gap.	Scattering lumps of the hard rock above ledge and portion of shoal projecting into channel below the ledge should be removed, using stone to build barrier along ledge and thence down-stream parallel to channel; 140 cubic yards of rock.
E	135.4	Taylor's Bluff Shoal.	....do	1,000	0.63	2.0	230 to 300	This shoal consists of a hard flint rock. Its worst portion is near the upper end, where the channel passes sharply from the left to the right bank.	Rocks should be removed for 80-foot channel through shallow crossing at upper end, also a few isolated lumps of rock below, using removed rock to build barrier from each bank toward channel. About 420 cubic yards of rock.
D	137.9	Collier's Bluff Shoal.	....do	400	0.24	2.4	250	Where the river is shoalest a ledge of rock extends from the left bank, just above two islands, to within 45 feet of right bank. The channel passes along right side of river through this gap.	Isolated lumps of rock, and end of ledge with shoal rock near it, should be removed to widen channel here to 60 feet, using removed rock to further confine flow of water to channel. About 50 cubic yards of rock.
C	142.1	.....	Sand-bar.....	300	0.10	3.0	270	Bar formed across river at head of island. Channel is on left side of river to upper end of bar, where it makes for head of island, passing just to left of head of island and then back to left side of river.	

*Letters refer to detailed surveys.

†Referred to summer low water.

Number.*	Distance from forks.	Name.	Nature of obstruction.	Length.	Fall from pool to pool.	Channel depth of least cross-section.†	Width of river.	Description.	Remarks.
	Miles.			*Feet.*	*Feet.*	*Feet.*	*Feet.*		
47	143.6	Cypress Point					90	At Big Indian Creek the river makes a sharp turn to left, and just below this bend on the right bank is a projecting point, narrowing the river to about 90 feet; the current is very swift.	Steam-boats running down-stream could, with difficulty, avoid this point. It should be removed. About 400 cubic yards of earth and 10 cypress trees from 1 foot to 3 feet in diameter.
48	147.0		Projecting points				60 to 210	Two quickly succeeding points on opposite sides of river, the lower at a narrow cut, and swift current, make an almost impossible set of turns for boat running down-stream.	Nearly straight channel should be secured by enlarging a cut-off, now 15 feet wide and 200 feet long, through upper point to an 80 foot channel. Removal of about 3,500 cubic feet of earth, and 100 trees averaging 1 foot in diameter.
B	155.5		Sand-bar	500	0.12	3.0	260	Bar formed at the lower end of "The Long Stretch;" sufficient channel close to right bank.	
50	159.0		Cut-off					Two short cut-offs 15 and 20 feet wide; moderate banks.	Should be closed.
51	160.4		Projecting points					Two quickly succeeding points of land on opposite sides of river combine to make a very serious and difficult set of turns for boats running down-stream.	Lower point should be removed, necessitating removal of about 3,800 cubic yards of earth and 50 trees averaging 1 foot in diameter.
52	160.7		Cut-off					Twenty-five feet wide	Should be closed.
53	162.9		do					do	Do.
54	163.1		do					Three hundred feet long; 25 feet wide	Do.
55	165.3		do					Twenty feet wide; low bank	Do.
56	173.8	Indian Cut-off	do					Long, narrow cut-off	Do.
57	177.2		do					Short; rather bad	Do.
58	178.4		do					Not bad	Do.
59	183.9		do					Ten feet wide; short; rather bad	Do.
60	188.8	Tobesofkee Cut-off.	Cut-off					Large and dangerous cut-off	Do.
61	196.7	Cherries Bluff Bar.	Sand-bar			2.9	150	Shallow crossing from right to left bank. It is believed that when river is cleared and navigation is opened no trouble will be experienced here.	
62	197.6		do			2.9	200	Bar caused by snags and tree	One tree and two snags should be removed.

63	198.8	.....	....d o.....	.....	.....	2.9	150	Shallow crossing; probably will not trouble when river is cleared.	
64	199.5	Buzzards' Bar	....do	.....	.....	2.8	250	Shallow crossing from left to right side of river.	Works of contraction necessary. Jetties should be built outward from left bank; probably 140 feet of jetty necessary.
65	200.1	Loggy Bight.....	Sand.....	.....	.....	2.6	250	Shallow place in bight caused by large accumulation of snags and trees.	Six trees, six logs, and ten snags should be removed.
66	200.2	Gravelly Bar	Sand and gravel-bar.	.....	.....	2.5	250	Long bar across river. Channel naturally about in center.	Contracting jetties are necessary here to confine the flow. About 350 feet of jetty work probably necessary.
A	202.0	.....	Sand-bar.....	450	0.10	2.0	300	Bar at head of island, where channel crosses from left to right bank.	Contracting jetties, aggregating about 420 feet long, should be constructed here.

*Letters refer to detailed surveys.

†Referred to summer low water.

As noted in the table above, letters in the column of "numbers" refer to places where detailed surveys were made; the "channel depths at least cross-section" are of course given below summer low water, and the estimate of cubic yards of rock excavation is as it lies at the bottom of the river.

To recapitulate, then: Between Macon and Hawkinsville there are five rock shoals (Nos. H, G, F, E, and D), three bars (Nos. 64, 66, and A), two cut-offs (Nos. 59 and 60), and three points (Nos. 47, 48, and 51) that must be improved to put this portion of the river in navigable condition (besides removing trees and snags and remodeling the bridges). Besides these, there are eight cut-offs that should not be allowed to enlarge through delay in filling them.

On the navigated portion of the river there are three rock shoals (Nos. M, L, and J), one bar (No. T), and six cut-offs to be closed (Nos. 13, 17, 19, 20, 29, and 31) that urgently require attention. Besides, then there is one cut-off (No. 18) to be opened, one cut (at No. 21) that should be made, one shoal (No. I) to be improved, the channel to be straightened at one shoal (No. 33), the aggregation of trees and snags at two sand-bars (Nos. U and K) to be removed, and twelve cut-offs that should be closed before they enlarge further.

An index map of the river as surveyed has been platted on a scale of $\frac{1}{144000}$, showing on one sheet the river from Macon to the Forks, in as close detail as is possible to such a scale.

The general map of the river is in eleven sheets, drawn on a scale of $\frac{1}{9600}$. It is expected that every essential detail of the river is shown closely as it is in fact; however, minor details, such as the exact position of the less prominent points or the configuration of slightly receding banks of the river, where they occur at some distance from the stations, are likely to be relatively rather than absolutely correct; such accuracies would necessitate the frequent stations and sights of an elaborate and long extended survey. It may be, too, that some details, such as the less well known cut-offs, banks, heights, etc., are incomplete between Abbeville (93.8) and Mobley's Bluff (53.7) as the river was overflowing its banks when the survey of this portion of its course was made.

It is intended that the general map of the river shall be as complete in every way as possible, giving the general meandering of the river and topography of the river banks, names, and locations of cities, landings, bluffs, creeks, cut-offs, rivers, shoals and bars; the location and description of bench-marks and gauge staves; the course of the channel with soundings; the stage of water at different portions of the river when each was surveyed; the location of bridges, of detailed surveys made, and of river gaugings and cross-sections of river and river valley. Whenever rock bottom was found it is shown by shading the river bed; the mile points indicated on the map were fixed by measurement along the given channel with an opisometer.

The maps of the 22 detailed surveys made are in four sheets and are drawn to a scale of $\frac{1}{1200}$. These surveys were made whenever it appeared that the depth might encroach on the proposed channel depth of three feet at summer low water.

The method followed in making these surveys was for the rodman to occupy the row boat, with the leadsman for sounding, one boatman at the oars and the other boatman holding the stadia rod vertically in the boat. The transit man, occupying a station on the bank, would direct the movements of the boat. When beginning the detailed survey the boat would cross the river from bank to bank and then drop down stream about 100 feet and recross the river, soundings being taken and recorded all the time. At the same time the transit man would take readings on the stadia rod for distance and direction as frequently as possible, these observations being correspondingly numbered by both transit man and rodman as they are called out, the rodman (who was recording soundings) entering each observation opposite its corresponding sounding. In this way soundings were instrumentally located every 40 or 50 feet, and in platting the intermediate soundings are spaced between these observed.

In the maps of the different detailed surveys, besides the general features of each place are shown rock ledges, barriers, and rock bottom; contours 3 feet below summer low water in orange and 5 feet below summer low water in blue; and the position of the channel (usually 80 feet wide, but in three cases narrowed to 60 and in two to 45 feet). Below each map of a detailed survey is its profile, showing water-line, at the time the survey was made, in blue, and summer low-water line in red, and the mid-channel and least channel depths. The letters used to designate shoals or bars in the table of obstructions above correspond to the letters of these detailed surveys, as platted.

The profile of the river is platted continuously and on a horizontal scale of 2 miles to an inch and a vertical scale of 12 feet to an inch. At this scale the slope of the river is plainly shown, while it is still possible to show all the variations in depth and to make prominent the lesser depths where there are shoals and bars.

The elevations given are above the mean low water of the sea at Darien, as reduced through the Altamaha River survey, 1889, from the Forks to Darien.

It will be observed that the fall of the river is quite uniform, averaging 0.964 feet per mile, and nowhere varying more than 14 feet from a straight line connecting Macon and the Forks. For 15 miles below Macon the slope is comparatively small being 0.807 feet per mile. From this place (188 miles) to a point 147 miles from the Forks the fall averages 1.305 feet per mile, the greatest fall (180 to 179 miles) being 2.7 feet. From 147 miles to the Forks the fall is again smaller and comparatively uniform, averaging 0.885 feet per mile. Some of the long reaches show a quite slight fall, 1 mile in the middle portion of the river (125 miles) showing a fall of less than 0.2 feet.

In making the profile of the river the water surface at the time of the survey (as given by turning point elevations, with the channel distances scaled from the general map) was first platted, and the mid-channel depths were then drawn in. Points on the flood line of the highest water known (August, 1887) are platted wherever such points could be found, and are connected by a broken line of blue, as is also the moderately high water of August, 1889, for a distance below Macon Names of places, creeks, etc., and the elevations of bench-marks, of the lower chord of bridges, and of the zero of the different gauges are shown. From this profile the elevation and distance from the forks of any place may be readily taken.

For determining the summer low-water line, comparison of the gauge readings at Macon, Abbeville, and Lumber City was first made. To determine the low-water readings of different gauges they should be compared through a low-water stage as long continued as possible, and one unaffected by local rains. A low water that seems to answer the purpose well, which was of about three weeks' duration and which showed corresponding fluctuations at all three gauges, occurred in October, 1889. At this time the river reached its lowest stage during the season. The lowest recorded readings of the Macon gauge at this time were from October 16 to October 24, and was 1.9 feet. At Abbeville (October 19–25) the gauge read 11.7 feet, and at Lumber City (October23–25) the rading of the gauge was 11.8 feet. There was a low water in September, 1889, at which time the Macon gauge read 2.1 feet; the Abbeville gauge 12.1 feet, and the Lumber City gauge 12.5 feet. This low water was of short duration and was apparently influenced by local rains in the lower part of the river's course, and so it is less reliable than the October low water for determining corresponding summer low-water readings.

The reading of the three gauges at the October low water, as given above, are taken as the summer low water. No gauge-readings for the low-water season of 1888, or before, are recorded, and consequently the only information, before the periods given, are the statements of men conversant with the river. Information obtained from such men indicates this low water of October, 1889, as about the average of the low waters of the different seasons. During the season of 1888 the river was nnusually high, not reaching the low-water mark of October, 1889, within, perhaps, 0.5 feet.

A number of years ago occurred an extreme low water. At this time the river at Hawkinsville was about 1.1 feet below the established summer low water, as shown by Captain Lassiter; information given by Captain Day indicates that the low water at Lumber City at the same time was about 1 foot below the established summer low water. So that the summer low water of different seasons fluctuates above and below this summer low water as given, at extreme low water reaching a stage a foot below this established summer low water.

After taking the summer low-water reading of the Macon gauge as 1.9, of the Abbeville gauge as 11.7, and the Lumber City gauge as 11.8, the summer low water through the whole length of the river was fixed by reductions depending on the gauge-readings taken by the survey party as the survey progressed and modified as necessary by the rise or fall of water at the established gauge staves. Generally the rise or fall recorded on the survey agreed reasonably well with the change of water-level which actually occurred between succeeding gauge staves while the survey was made between them. This comparison as deduced and applied to the purpose of platting the summer low-water line is as follows:

Between Macon and Hawkinsville:

Feet.

4.3 = reading of Macon gauge when survey was begun.
1.9 = summer low water by Macon gauge.
2.4 = water above summer low water at Macon.
0.5 = stage of water at Hawkinsville when survey reached that place, as indicated by guage-readings up to the day before, etc.
1.9 = fall to be accounted for between Macon and Hawkinsville.

Feet.

Also, Macon gauge read 4.3 when survey was begun.
Macon gauge read 2.1 four days before survey reached Hawkinsville (it taking abont four days for flood to advance from Macon to Hawkinsville).
2.2 = corresponding fall at Macon.

The Hawkinsville gauge shows about the same fall.

During the same time the readings taken by the survey party indicate a fall in the aggregate of 2.8 feet. Consequently these flat-gauge readings are reduced about one-quarter for this distance, and correspondingly decreasing reductions from the surface of the water are made to the summer low-water line; these reductions are given in the table, Appendix C.

Between Hawkinsville and Abbeville the rise of water to be accounted for is 4.8 feet, as thus found:

Feet.
17.0 = reading Abbeville gauge, when survey reached Abbeville.
11.7 = summer low-water line on Abbeville gauge.
5.3 = water above summer low water at Abbeville, when survey arrived.
0.5 = stage of water at Hawkinsville when survey left.
4.8 = rise between Hawkinsville and Abbeville.

There are no data giving the rise at Hawkinsville, but at Abbeville (for the included time of survey less two days, the time of flood advance between the two places), the rise was 4.5 feet, naturally less, as Abbeville is farther down-stream.

The rise as recorded on the survey was 5.14 feet. The difference between 5.14 feet and 4.80 feet is distributed through this distance, as given in table.

Between Abbeville and Lumber City the river rose about a foot at first and then fell continuously; the actual fall was about 4.9 feet, as follows:

Feet.
12.2 = reading Lumber City gauge when survey arrived.
11.8 = summer low water by Lumber City gauge.
0.4 = stage of water at Lumber City.

When survey arrived:

Feet.
5.3 = stage of water at Abbeville, as above.
0.4 = stage of water at Lumber City, just given.
4.9 = net fall to be accounted for.

During the same time (less four days for the progress of floods from Abbeville to Lumber City) the fall of the Abbeville gauge was 4.8 feet and the Lumber City gauge 4.4 feet.

The rise recorded by the house-flat was 1.05 feet and the subsequent fall to Lumber City 5.73 feet, making a net fall between the two places of 4.68 feet. This difference between 4.68 feet and 4.90 feet is distributed through this distance.

From Lumber City to The Forks there was slight change in the river, the house-flat recording a fall of 0.11 feet.

The summer low-water line was platted parallel to the water surface as actually observed on the survey, as the refinement of slope, due to the widening or contraction of the banks at different points, the presence of bars, shoals, and other modifying features, would be long and tedious and would make not much difference in detail and none in general slope. Appendix C gives the table of reductions from the observed water-surface to summer low water as they are deduced and applied.

I have attempted to obtain elevations from the Georgia Railroad at Macon, the Central Railroad at Macon, the Savannah, Americus and Montgomery Railroad at Abbeville, and the East Tennessee, Virginia and Georgia Railroad near Macon and at Hawkinsville and Lumber City, to use as checks on my level line. The East Tennessee, Virginia and Georgia Railroad reply that their levels are in such shape that they can not furnish elevations to this office; the Central Railroad has changed its grade at Macon since its profile was made and reliable information of present grade can not be had. Three checks on the surveyed line have, however, been deducted by the aid of elevations furnished by the Georgia Railroad by Mr. Hamilton Wilkins, R. M., and by the Savannah, Americus and Montgomery Railroad by Mr. R. E. Hardaway, superintendent.

The first comparison deduced involves the whole length of the Ocmulgee River survey, and was obtained by taking the Georgia Railroad elevation from Macon to Milledgeville and Mr. A. S. Cooper's elevations, in Oconee River survey of 1889, from Milledgeville to The Forks, and comparing the difference of elevation between Macon

and The Forks, thus found, with my own difference of elevation of these two points. The figures are as follows:

	Feet.
Elevation of base rail Georgia Railroad Bridge, Oconee River—railroad elevation	311.03
Elevation low water, Ocmulgee River at old Georgia Railroad crossing—railroad elevation	290.03
Georgia Railroad Bridge, Oconee River, above low water, Ocmulgee River	21.00
Mr. Cooper's elevation base rail Georgia Railroad Bridge, Oconee River (arbitrarily)	315.71
Mr. Cooper's corresponding elevation B. M. No. 42, at Forks	107.30
Difference elevation, Georgia Railroad Bridge at Oconee River and B. M. No. 42—Oconee River survey	208.41
Georgia Railroad Bridge, Oconee River, above low water Ocmulgee River	21.00
Difference elevation, low water Georgia Railroad Bridge, Macon, and B. M. No. 42 at Forks, via Georgia Railroad and Oconee River	187.41
Ocmulgee River survey elevation, low water at old Georgia Railroad crossing, near Macon	278.60
Ocmulgee River survey elevation B. M. No. 42 at Forks	90.24
Difference elevation, low water, Georgia Railroad Bridge, near Macon, and B. M. No. 42 at Forks, via Ocmulgee River	188.36

It will be seen that these two differences of elevation between Macon and The Forks, by these two different circuits, differ 0.95 foot.

The second comparison deduced involves the present survey from Abbeville to The Forks and was obtained by taking the Savannah, Americus and Montgomery Railroad's elevations from Abbeville to Mount Vernon, and Mr. A. S. Cooper's elevations from Mount Vernon to The Forks, and, comparing this difference of elevation between Abbeville and The Forks with my own difference between the same points, as follows:

	Feet.
Elevation, low water, Ocmulgee River, Savannah, Americus and Montgomery crossing at Abbeville, railroad elevation	164.00
Elevation, low water, Oconee River, Savannah, Americus and Montgomery crossing at Mount Vernon, railroad elevation	110.00
Difference of elevation, low water, at Abbeville and Mount Vernon, railroad elevations	54.00
Mr. Cooper's elevation, low water, at Savannah, Americus and Montgomery crossing at Mount Vernon (arbitrarily)	131.40
Mr. Cooper's corresponding elevation, B. M. No. 42, at Forks	107.30
Difference in elevation, Mount Vernon, low water, and B. M. No. 42, at Forks, Oconee River survey	24.10
Difference, elevation, low water, at Abbeville and Mount Vernon, railroad survey	54.00
Difference in elevation, low water, Savannah, Americus and Montgomery crossing, Abbeville, and B. M. No. 42, via railroad and Oconee River	78.10
Ocmulgee Survey elevation, low water, at Savannah, Americus and Montgomery crossing, Abbeville	169.30
Ocmulgee Survey elevation, B. M. No. 42, at Forks	90.24
Difference in elevation, low water, Savannah, Americus and Montgomery crossing at Abbeville, and B. M. No. 42, via Ocmulgee River	79.06

It will be noticed that these differences of elevation between Abbeville and The Forks, by these two different circuits, differ 0.96 foot.

The third comparison involves the present survey from Macon to Abbeville, and was obtained by taking the Georgia Railroad elevations from Macon to Milledgeville; Mr. A. S. Cooper's elevations from Milledgeville to Mount Vernon, and the Savannah, Americus and Montgomery Railroad elevations from Mount Vernon to Abbeville, and

comparing the difference of elevation thus found with my own difference of elevation between these two points, as follows:

	Feet.
Mr. Cooper's elevation, base rail, Georgia Railroad Bridge, Oconee River (arbitrarily)	315.71
Mr. Cooper's corresponding elevation, low water, Savannah, Americus and Montgomery Railroad crossing, Mount Vernon	131.40
Difference in elevation, Georgia Railroad Bridge, Oconee River, and low water at Mount Vernon, Oconee River survey	184.31
Georgia Railroad Bridge over Oconee River, above low water, Ocmulgee River, as given above	21.00
Low water, Oconee River, Mount Vernon, below low water, Ocmulgee River, near Macon	163.31
Low water, Oconee River, Mount Vernon, below low water, Ocmulgee River, Abbeville (as above)	54.00
Low water, Savannah, Americus and Montgomery Railroad, Abbeville, below low water near Macon, via Georgia Railroad, Oconee River and Savannah, Americus and Montgomery Railroad	109.31
Ocmulgee survey elevation, low water Old Georgia Railroad, crossing near Macon	278.60
Ocmulgee survey elevation, low water, Savannah, Americus and Montgomery crossing, Abbeville	169.30
Low water, Savannah, Americus and Montgomery Railroad, Abbeville, below low water near Macon, near Ocmulgee River	109.30

It will be seen that these differences of elevations between Macon and Abbeville by these two different circuits differ 0.01 foot.

Cross-sections of the river and current gaugings for discharge measurements were made at Hawkinsville, Abbeville, and Lumber City; current observations for discharge were taken at Macon in August, 1889, by Mr. A. S. Cooper, assistant engineer, the results of whose observations are on file in this office, from which I obtained the information concerning the cross-sections, amount of discharge, etc., at Macon, given below. Cross-sections of the river valley were also made at these same points, extending to above the freshet line, and made by compass and stadia observations for direction, distance, and elevation.

At each place where observations for discharge were made, three cross-sections, 100 feet apart and at right angles to base line, were sounded out; the soundings being about 10 feet apart and located by stadia sights from stations on the base line. For obtaining current velocities rod floats were used. These floats had a course 200 feet long (between the extreme sections) and were run every 10 or 15 feet of the river's width. Observations were taken on these floats as follows:

The transit man was stationed at the upper section to observe the point at which the float crossed the first section (as given by reading on stadia-rod in boat crossing directly after the float); the rodman was in the boat to attend to the float; and one of the men was stationed at the third section to call out when the rod float crossed that section as given by range poles. The position of each float was thus given at the first section by stadia sight, and at the third section by angle from base line at the transit at the instant the man on third section range calls out its crossing there. The time of the crossing of the float was taken by transit man by observation at the first section, and by recording the time given by man on third section, as stated above.

I have platted these three Hawkinsville sections and have drawn a mean section of the three sections, the area of the mean section being one-third the sum of the areas of the three sections as found with the planimeter. The same was done with the Abbeville and Lumber City sections. These mean sections are the ones used in computing the volumes of discharge.

I have also platted the course of the floats at each of the places of velocity measurement. The formula used in obtaining the velocity of filament from velocity of rod is also given on this same sheet, and is the old formula of J. B. Francis,

$$V_m = V_r\,[1 - 0.116\,(\sqrt{D} - x)]$$

but with a modified value of x depending upon the ratio of length of rod to depth of water. Opposite each sketch is given a table showing the lengths of rod, depth of water (as scaled from each mean cross-section, in which I have drawn each rod in its position), time and velocity of rod, values of constants in the formula just referred to, and the velocity of whole filament. Upon the mean section I have platted

the corresponding velocities and have drawn the indicated velocity curve. Then dividing the cross-section into compartments, I have taken the area and mean velocity of each compartment and have thus computed the discharge, as shown in detail on the cross-section sheet.

At the time of the gaugings at Hawkinsville and Lumber City, the river was quite low, being about one-half foot above summer low water at both places. At Abbeville the river was about 5.5 feet above summer low water at a stage which river-men call "a good boating river." The results of the gaugings are as follows:

Place.	Stage of river. (Above summer low water.)	Area of section.	Mean velocity per second.	Discharge per second.
		Square feet.	*Feet.*	*Cubic feet.*
Macon	0.90	1,100.00	1.300	1,430.00
	10.10	3,762.00	3.155	11,870.00
	23.50	9,032.00	6.101	55,100.00
Hawkinsville	0.50	1,324.90	1.533	2,031.78
Abbeville	5.43	3,177.80	1.749	5,557.13
Lumber City	0.46	2,062.70	1.273	2 625.93

I have also platted the cross-sections of the river valley, taken at or near the gauging sections. The Hawkinsville section shows the valley wide and deep, the high water of 1887 here reaching an elevation of 30.93 feet above summer low water, and the area of the cross-section being about 30,720 square feet. The Abbeville section is very long, the width of the valley covered by the higher freshets being 12,000 feet. The flood height here is 19.27 feet above summer low water and the area 94,400 square feet. At the time of the freshet of 1887, the embankments, trestles and bridge shown were not constructed. The Lumber City section is about 3,400 feet long and the 1887 freshet reached a height of 19.84 feet above summer low water. The area of cross-section of this flood height is 29,040 square feet. At the Macon section the flood-line reached an elevation of 23.50 feet above summer low water and the area of cross-section 12,489 square feet.

While I was making observations for discharge the river fluctuated so little in its stage of water that it was not possible to obtain measurements at two different stages, from which I could construct an approximate velocity curve for that place, and so approximate to the velocity and discharge at freshet heights. I then tried the method of assuming a surface slope at freshet stages, basing the assumption on the general slope of land and knowledge of the general topographical features in the vicinity of each cross-section, from which I could compute, with the aid of data at hand, the mean velocity and so the discharge voided. But I find this method entirely too problematical in the present instances on account of the nature of the cross-sections. All of them, up to the river's bank, are more or less thickly covered with trees.

The Hawkinsville section has a roadway embankment on one side and a natural hill-side on the other, which converge and probably make the surface slope quite independent of the general slope of the land. The Abbeville section extends through the woods for over 2 miles, and the velocity through this section can not be large, as indicated by the flood height near the east side of the valley, being 2.81 feet lower than at the river; still there must be a considerable discharge through this swamp, and an entirely uncertain velocity, as a slight change in velocity through this large area would make a great difference in the result. The same is true of the Lumber City section, though to a less degree.

Neither did the areas of the unobstructed portions (at the river) of these sections, considered in connection with other data aid in securing satisfactory results. I am forced to the conclusion that the data obtainable are entirely inadequate to admit any reliable estimate of the freshet discharges of the lower river to be made; any satisfactory approximation will have to be based on observations taken at higher stages of the river.

Sketches (not to scale) of the bridges crossing the river have already been submitted.

The following is a tabulated description of the bridges:

Name of bridge.	Place.	Kind of bridge.	Total length.	Height between chords.	Width.	Grade height above S. L. W.	Remarks.
			Ft.		*Ft.*	*Feet.*	
Covington and Macon R. R.	1 mile below Macon.	Combination truss through bridge.	600	3 spans, 25 feet; 1 span 28 feet.	19	25.1	Four fixed spans of 120, 150, 150, and 180 feet; no draw. Piers, iron cylinders.
East Tenn., Virginia and Georgia R. R.	10 miles below Macon.	Howe truss through bridge.	316	24 feet	19	16.9	Two equal fixed spans; no draw. Spans rest on masonry piers.
East Tenn., Virginia and Georgia R. R.	Hawkinsville.	....do	320	22 feet	19	*33.0	Two equal fixed spans; no draw. Spans rest on stone piers.
County of Pulaski highway bridge.	....do	Iron through bridge.	200	24 feet	20	38.2	Single fixed span; no draw. Curved upper chord. Rests on built iron piers.
Savannah, Americus and Montgomery R. R.	Abbeville...	Iron through bridge (in course of erection.)	246	24 feet	15½	29.7	Bridge now about finished, of fixed span of 66 feet and draw of 180 feet. Piers of iron cylinders filled with concrete.
East Tenn., Virginia and Georgia R. R.	Lumber City.	Howe truss through bridge with draw.	440	20 feet (fixed span).	19	35.4	Two equal fixed spans of 145 feet and antiquated draw of 150 feet. Pile piers. New draw-bridge to be erected.

* About.

The history of the navigation of the Ocmulgee River extends through the present century. At first pole-boats were used, and later, steam-boats. In 1829 the first steam-boat reached Macon and from that time till the opening of the Central Railroad the river commerce increased. Fifteen steam-boats were on the river between 1833 and 1845 and the Ocmulgee towns from Macon down were in direct communication with the sea-ports. In 1845 the Central Railroad was completed to Macon. Since that time the upper Ocmulgee has had no regular line of boats, the railroad driving off the regular steam-boats by adopting a sliding schedule, of high rates when navigation was impeded by low water and low rates when navigation was good. After 1845 irregular trips on the Ocmulgee were made, steam-boats at times running as far as Macon until the building of the bridges between Macon and Hawkinsville and the making of the latter city the actual head of navigation. About fifteen years ago the uncertain service on the Lower Ocmulgee was improved by the establishment of a steam-boat line proposing to make regular trips. This regular service was quite practicable at good stages of water, but was found to be impossible at low stages. However, as the river has been improved the ability to make regular trips at lower stages of water has been correspondingly increased. During this time the river commerce has constantly grown and the steam-boat service improved. During the past season there have been 9 steam-boats on the river, 2 running from Hawkinsville to Abbeville and below, 3 from Lumber City for about 70 miles up the river, and 4 running from Abbeville to Brunswick, Ga.

These latter boats are owned by the Savannah, Americus and Montgomery Railroad and were necessary for the railroad as an outlet for its merchandise from its former eastern terminus, Abbeville. Building eastward the railroad has made connection with East Tennessee, Virginia and Georgia Railroad, and the line of boats being no longer necessary to the road it was discontinued in October last. Two of these steam-boats have since been chartered by private persons and now make regular trips to the sea, as before. The following is a list of the steam-boats on the Ocmulgee during 1889. All except the *Ida* are stern-wheel boats.

Name.	Length.	Beam.	Depth.	Gross tonnage.	Net tonnage.
	Feet.	*Feet.*			
Hawkinsville boats:					
Abba	106.0	26.0	4.4	240.26	120.13
J. C. Stewart	100.0	24.0	3.9	235.84	129.05
Abbeville boats (Savannah, Americus and Montgomery line):					
Swan	103.0	29.0	4.7	366.30	193.24
J. W. Sweeney	118.9	34.4	4.4	414.73	229.35
Abbeville	118.9	34.4	4.4	414.73	227.49
City of Americus	118.9	34.4	4.4	414.73	229.35
Lumber City boats (Captain Day's):					
Tommie	108.0	22.0	3.9	282.89	175.29
Ida	115.0	24.0	5.5	296.19	181.04
Lumber City	115.0	23.0	4.4	330.71	227.95

The commerce of the river consists of round and hewn timber rafted down the river to the mills and sea-ports, and the naval stores, cotton, grain, merchandise, camp supplies, etc., carried by the steam-boats.

The product of logs rafted in the Ocmulgee during the past year is placed by Mr. J. K. Clarke, of Darien, Ga., at 24,000,000 feet, board measure, and of hewn timber at 6,000,000 feet, board measure, the total valued at $300,000.

One of the most important products of the Ocmulgee region, and one which is mainly dependent on the river for transportation, is that of naval stores. I have obtained from the six factors dealing in this valley statements of the products shipped by boat from the country along the Ocmulgee River. The amounts given by these factors I have combined and tabulated by counties:

County.	1887–'88.		1888–'89.		Eight months of 1889.	
	Turpentine.	Rosin.	Turpentine.	Rosin.	Turpentine.	Rosin.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
Dodge	.....	....	1,162	3,673	510	1,534
Wilcox	3,084	10,277	5,199	20,080	8,660	20,793
Irwin	1,679	6,054	2,008	7,499	1,872	6,117
Telfair	3,916	14,937	3,700	15,120	4,467	13,118
Coffee	2,938	9,839	3,641	12,318	3,756	11,058
Montgomery (southwestern)	1,105	4,519	983	3,747	1,376	3,202
Appling (northwestern)	1,623	5,106	1,612	5,715	603	3,040
Total	14,345	50,732	18,305	68,152	21,244	58,862

It will be noticed that the returns for the season of 1889–'90 are incomplete, being obtained only from April 1 to December 1, 1889. The receipts for the remaining four months would be less than a proportional amount; owing to the low water in the river during the fall naval stores, and especially rosin, have accumulated at the landings and will be shipped during the winter months. Probably a fair estimate for the remaining four months would be less than one-third additional for turpentine and more than one-third additional for rosin, bringing the total for the year 1889–'90 to about 26,000 barrels of turpentine and 84,000 barrels of rosin.

Repeated efforts have been made to secure statements of the commerce of the river carried by the three lines of steam-boats given, but the agent of the Savannah, Americus and Montgomery boats is the only one who has replied. The following amounts are given by him as the carrying trade of this line of boats for the past year: Rosin, 60,000 barrels; turpentine, 10,000 barrels; cotton, 15,000 bales; hay, 5,000 bales; oats, 10,000 sacks; corn, 15,000 sacks; flour, 5,000 barrels; general merchandise, 2,000,000 pounds; railroad steel and iron, 1,700 tons; salt, 10,000 sacks; guano, 20,000 sacks; miscellaneous, 800 tons. The value of the above shipments is about $1,455,000.

Of the five remaining steamboats, two have not been used much during the year and one other engages also in the Oconee River trade; still these boats make much more frequent trips than have the railroad boats and have also been running more regularly. I should, then, estimate the value of shipments by the Hawkinsville and Lumber City boats at from 80 to 100 per cent. of that of the Abbeville boats, or about $1,300,000.

The total value of the present river commerce may then be estimated as follows:

Shipments by Abbeville boats (Savannah, Americus, and Montgomery Railroad)	$1,450,000
Estimated shipments by Hawkinsville and Lumber City boats	1,300,000
Value of logs and hewn timber rafted	300,000
Total	3,050,000

Bordering on the Ocmulgee River between the natural head of navigation, at Macon, and the Forks are the following counties: Bibb, Twiggs, Houston, Pulaski, Dodge, Wilcox, Irwin, Telfair, Coffee, Montgomery, and Appling. These counties (taking only parts of three last named), with portions of Monroe, Crawford, and Jones counties, which lie close to Macon, may fairly be considered as comprising the territory naturally tributary to the Ocmulgee River. In this territory is Macon, a city of about 30,000 (including its suburbs), which is the important railroad, manufacturing, and commercial center of central Georgia; and Hawkingsville, a town of about 3,000 inhabitants and also a distributing point for its surrounding territory.

This country lies in the long-leaf pine and wire-grass region, and in its upper part the growth of valuable hard woods is extensive. The estimated amounts of long-leaf pine (board measure) in this region are given below, as returned by the comptroller-general of the State of Georgia; and the hard woods are estimated by Messrs. A. G. Butts and J. C. Butler, of Macon, and approved by the comptroller-general, and given in feet, board measure:

County.	Long-leaf pine.	Hard wood.
Monroe, (one-half)	Lacking	Lacking.
Crawford (one-half)	Lacking	Lacking.
Jones (two-thirds)	27,000,000	43,000,000
Bibb	38,000,000	256,000,000
Twiggs	84,000,000	256,000,000
Houston	191,000,000	153,600,000
Pulaski	485,000,000	422,400,000
Dodge	417,000,000	332,800,000
Wilcox	292,000,000	307,200,000
Irwin	488,000,000	128,000,000
Telfair	598,000,000	601,600,000
Coffee (one-half)	289,000,000	160,000,000
Appling (one-eighth)	68,000,000	14,400,000
Montgomery (one-twelfth)	66,000,000	9,600,000
Total	3,043,000,000	2,684,600,000

Valuing the standing pine at $1.50 per thousand, the value of the above amount would be $4,564,500: and the hard woods at $3.50 per thousand, would then have a value of $9,396,100.

The present population of this country is estimated by the Macon Board of Trade at about 175,000.

In the following table the acreage of tilled lands is furnished by the Macon Board of Trade, basing their estimate on the returns of the Tenth United States Census; the remainder of the table is from the report of the comptroller-general of Georgia, for 1888-'89:

County.	Total acreage.	Acres of tilled land.	Value of real estate.	Value of personal estate.	Total value of whole property.
Monroe (one-half)	146,660	77,798	$746,498	$501,271	$1,247,769
Crawford (one-half)	102,468	41,461	244,164	127,436	371,600
Jones (two-thirds)	163,301	66,199	545,887	282,278	828,765
Bibb	157,702	73,051	8,195,915	4,948,545	13,144,460
Twiggs	200,017	93,870	614,597	143,071	757,668
Houston	357,140	237,758	1,837,012	883,252	2,720,264
Pulaski	285,896	117,267	1,091,644	801,598	1,893,242
Dodge	398,675	32,859	603,560	726,638	1,330,198
Wilcox	348,797	25,521	404,340	338,934	743,274
Irwin	508,862	16,321	456,135	464,368	920,503
Telfair	289,108	19,774	382,681	372,944	755,625
Coffee (one-half)	376,973	12,332	298,072	394,061	692,133
Appling (one-eighth)	86,299	2,305	62,056	82,028	144,084
Montgomery (one-twelfth)	42,291	3,408	46,006	47,872	93,878
Total	3,464,189	819,924	15,528,567	10,114,896	25,643,463

The resources of this country are mainly farm products, timber products, and manufactured goods.

The following tables of values of the farm products of these counties is estimated from a table of productions prepared by the Macon Board of Trade, which considers the yield for the past year as 40 per cent. greater than the returns given in the United States Census for 1880:

County.	Value of cotton produced.	Value of oats, wheat etc., produced.	Value of Indian corn produced.	Value of sugar and molasses produced.
Monroe (one-half)	$401, 943	$60, 976	$93, 596	$655
Crawford (one-half)	203, 326	16, 828	56, 586	2, 200
Jones (two-thirds)	332, 963	29, 061	95, 009	563
Bibb	352, 643	36. 762	107, 972	1, 381
Twiggs	494, 629	10, 553	131, 746	1, 304
Houston	1, 149, 734	97, 198	277, 715	7, 068
Pulaski	590, 261	19, 363	190, 366	8, 260
Dodge	581, 876	8, 812	56, 478	20, 778
Wilcox	80, 109	11, 642	48, 224	8, 103
Irwin	35, 819	16, 304	30, 098	3, 518
Telfair	.....	8, 768	39, 193	.....
Coffee (one-half)	17, 781	12. 545	22, 896	156
Appling (one-eighth)	2, 849	2, 220	5, 544	1, 584
Montgomery (one-twelfth)	4, 271	1, 763	5, 512	917
Total for 1889	4, 248, 204	332, 795	1, 160, 935	56, 487

County.	Value of potatoes produced.	Value of orchard products.	Value of miscellaneous products.	Totals.
Monroe (one-half)	$18, 167	$12, 846	$260	$588, 443
Crawford (one-half)	12, 607	3, 295	240	295, 082
Jones (two-thirds)	19, 378	11, 570	635	489, 179
Bibb	36, 514	3, 942	6, 552	545, 766
Twiggs	18. 885	4, 111	348	661, 576
Houston	56, 556	15, 947	792	1, 605, 010
Pulaski	39, 544	3, 574	.....	851, 368
Dodge	81, 176	1, 216	324	750, 660
Wilcox	24, 158	4, 125	217	176, 578
Irwin	41, 794	140	2, 129	129, 802
Tolfair	.....	7, 026	.....	54, 987
Coffee (one-half)	14, 632	3, 785	163	71, 958
Appling (one-eighth)	3, 427	811	756	17, 191
Montgomery (one-twelfth)	2, 503	663	66	15, 695
Total for 1889	369, 341	73, 051	12, 482	6, 253, 295

The timber products are logs, naval stores, and lumber. The value of logs from this region last year has been stated as about $300,000. The value of naval stores, computed from the table of shipments of naval stores given above, and allowing for the additional rosin and turpentine indicated by the factors as shipped by rail, is about $454,900. The lumber produced in these counties last year is estimated by Stilwell, Millen & Co., of Savannah, dealers in lumber from this region, at 100,000,000 feet, valued at the mills at about $1,200,000. The total value of the year's timber products would then be about $2,454,900.

The value of manufactured products it is difficult to obtain. The Tenth United States Census gives as the value of such from the region considered in 1880 as $2,588.325. The same report gives the value of Bibb County's manufactured goods as $1,724,125, while Macon, Bibb County, claims for the same in 1889 $4,822,000. It is doubtful if the whole area would show a proportionate increase. Supposing that the value of the products of manufacture had doubled since 1880, the annual value would now be over $5,000,000.

Traversing this Ocmulgee region is the East Tennessee, Virginia and Georgia Railroad, running through the river valley from Lumber City to Macon; the Savannah, Americus and Montgomery Railroad, crossing the valley at Abbeville; and the Central Railroad, the Georgia Railroad, the Covington and Macon Railroad, and the Georgia Southern and Florida Railway, all passing through the upper part of the valley at Macon. These railroads, with the river, form the commercial highways of this territory, and their carrying trade represents the commerce of this region. The total

receipts and shipments of the railroads from each city and town of the Ocmulgee region it has been impossible to obtain. However, the railroads centering at Macon (including all but one given above) have furnished the following totals of their shipments and receipts at Macon proper for the year 1888-'89:

	Freight.	
	Received.	Sent.
East Tennessee, Virginia and Georgia Railroad.....pounds..	231,994,721	114,988,677
Central Railroad.....tons..	87,927	55,749
Georgia Railroad.....do...	21,110	10,995
Covington and Macon Railroad.....do....	28,536	18,765
Georgia Southern and Florida Railroad.....pounds..	15,963,825	25,791,159

The total of Macon's commerce, then, as just given, amounts to 417,451 tons. Of this amount from 20 to 30 per cent., or perhaps 105,000 tons, is northern and northwestern freight; the remainder may be considered as comparatively local. Computing the average rate per ton on the distant freight at $7.50, and on the more local freight at $2.10 per ton, we get the amount paid annually by Macon in freights to be about $1,443,650. In estimating upon the freight traffic of the remainder of the Ocmulgee region it is to be borne in mind that Macon is the commercial center and distributing point for a large region, and its business is really and comparatively large; the larger part of the tonnage of the remainder of this region is the commerce of Hawkinsville and the shipment of lumber produced; and altogether it would, perhaps, amount to from 35 to 50 per cent. of Macon's tonnage. Making some deductions for the part of this estimated tonnage that is already considered in Macon's tonnage, we may consider the freights paid in these counties outside of Macon as about $550,000. The total would, then, be about $1,993,650.

The question of how far the direct effect of improved navigation upon the Ocmulgee River would extend depends mainly on the quality of service offered by steam-boats, the character of the commodities constituting the commerce of the country, the comparative length of haul to railroad and river, and on comparative tariff rates.

Good steam-boat service, of course, requires a good river, when regular trips can be made at both high and low water. The chief drawback at present in the Ocmulgee service is the irregular trips of steamers and their complete stoppage at very low stages of water by the obstructions that call for improvement. A regular, reliable schedule time, which the improvement of the river would make possible, is the need of Ocmulgee navigation. Were the river made navigable at all stages and its communication with the sea-coast through the Altamaha River reliable, advantage would be taken of its condition and regular schedule trips probably be made. Captain Day, owner of the Lumber City boats, contemplates adding another steamer to his line. Hawkinsville business men are considering the question of establishing a regular line of steam-boats to engage much more extensively in river commerce than at present; and the Macon business men are entirely interested and await the re-opening of the river between Hawkinsville and Macon, when they intend to establish a line of steam-boats running from Macon to the sea-coast at Savannah or Brunswick, Ga.

Some of the products of the Ocmulgee country require a navigable river for their development. The round and hewn timber and naval stores of the lower river are mainly dependent on this river for transportation. Cotton, grain, camp supplies, and other such bulky and not perishable freights naturally take advantage of the cheaper transportation by river. Between Hawkinsville and Macon there is a great region of hardwood timber that awaits the opening of the river to be developed. All these will furnish an extensive source of supply from which river freights will be drawn.

When the general directions of a river and of a railroad are parallel, the distance from the river at which the bulkier commodities will naturally seek the river may be taken as two-thirds the distance between them. Of course, this depends on comparative tariff rates, but were rates fixed according to corresponding actual cost of transportation by rail and river the above statement would probably be true. With this supposition, on the lower 150 miles of the river there is a strip of country on the east and north side of the Ocmulgee, between it and the East Tennessee, Virginia and Georgia Railroad, varying from 5 to 15 miles in width, and on the west and south side of the river a district from 12 to 20 miles in width, whose commerce naturally belongs to this river. The Savannah, Americus and Montgomery Railroad is the only railroad crossing this territory. For the upper 50 miles of river, nearer Macon, the railroads gradually converge.

This valley designated has an area of about 2,400 square miles. In it is more than half the property (in value) and the principal part of the manufacturing industries of the Ocmulgee River counties, and it contains a good proportion of the valuable pine and a large part of the hard woods of this country. The Macon Board of Trade estimates the increase in value of the lands in the counties between Macon and Hawkinsville which would result from the opening of the river between the two cities at $24,706,764, and the inreased revenue to the State from wild lands in the same region at $45,000 per annum, and from improved lands at $150,000 per annum. In this valley just designated are Macon, Hawkinsville, Abbeville, and Lumber City, the largest places of the tributary country, and the natural course of commerce would call to the river's carrying trade the more bulky and imperishable commodities of their extensive commerce. The natural products of this territory lying along the river are now mainly timber and naval stores, though cotton and other products of the farm are raised. Probably in ten or fifteen years the timber products will cease to increase, and then the cotton, grain, and other productions of the farms as they increase in quantity, will gradually take the place of timber and naval stores, and still furnish a constant and legitimate supply for the river's carrying trade.

The main consideration affecting the river's commerce is, of course, the comparative tariff rates of river and railroads. In considering this question the discussion is naturally divided into local and joint tariffs. Coming under the latter head is only one point in the Ocmulgee County—Macon—at which competition of different lines of railroads affects the tariff rates, and Macon is now beyond the influence of navigation. Still, an inference may be drawn from the fact that the railroads now charge about $1.50 per bale for cotton from Macon to the sea-ports, when it was carried by steam-boats when the Ocmulgee was navigated as far as Macon, at $1 per bale; and there is no reason why, with the increased commerce of Macon, river tariff rates should not now be established at a correspondingly low figure. The Macon Board of Trade states that in their opinion Macon shippers would save at least 37 per cent. of the amount now paid for transportation by rail were the Ocmulgee River in navigable condition.

In considering the local tariffs, comparison is made between the rates of the navigated portion of the Ocmulgee and those of the parallel railroads to stations opposite this portion of the river. Steam-boat rates, as given by the Savannah agent, are the same to the different Ocmulgee landings, from the sea-coast, without regard to distance; the railroad ra es (given below) are taken from the railroad tariff schedules, for the average distance to the stations opposite the Ocmulgee River landings from the same sea-ports (Brunswick and Savannah, Ga.)

Comparison of rates.

	Classes per 100 pounds.										Cotton per bale.	Rosin per barrel.	Turpentine, per barrel.
	1.	2.	3.	4.	5.	6.	A.	B.	D.	F.			
	Cts.	*Cts.*	*Cts*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*		*Cents.*	
Railroad	54	46	42	33	29	21	24	24	16	32	$1.90	75	$1.30
Steam-boat	90	75	63	54	43	32	25	20	14	35	1.35	33	.50

It will be seen that the railroads offer the advantage on the more perishable and lighter classes of freight, which decreases until the advantage is in favor of the boats for the heavier freights, while for cotton, rosin, and turpentine the steam-boat rates are from four-tenths to seven-tenths the railroad rates. Probably the high river rates on that part of the schedule above classified by numbers is mainly due to the fact that the lighter and more perishable freights are not desired on the river, where there is a chance of the suspension of navigation made necessary by low water, and consequent damage to such freights by uncertain delays. The steam-boat rates on these classes of freights is much greater than an extensive, regular, and reliable service would warrant. For the commodities now composing the river freights the tariff averages from two-thirds to three-fourths of the corresponding railroad rates.

The extent to which the indirect influence of reliable navigation of the Ocmulgee River would be felt is uncertain, depending on the combination of many and various influences. Still it is probable that with a good, navigable river to Macon steamboats would either carry a large proportion of the freights or oblige the railroads to lower their tariffs; and in either case the greater part of the interests of the country spoken of in this report as the "Ocmulgee Region" might be considered directly or

indirectly interested in the proposed improvement. And should the railroads adjust their rates so as to retain much of their present business, the large and increasing carrying trade of the lower river and its border country, the timber and other interests between Macon and Hawkinsville awaiting development, and Macon's extensive trade, will still furnish a legitimate field for a large river commerce.

There are transmitted with this report: (1) Index map of river (1 sheet); (2) general map of river (11 sheets); (3) twenty-two detailed survey maps (4 sheets); (4) profile of river (1 sheet); (5) cross-sections and velocity curves (1 sheet); (6) course of floats, with tables, etc. (1 sheet); (7) three appendices (tables A, B, and C); (8) nine field-books of the survey.

Very respectfully, your obedient servant,

J. L. VAN ORNUM, *Surveyor.*

Lieut. O. M. CARTER, *Corps of Engineers, U. S. A.*

O 13.

PRELIMINARY EXAMINATION OF SAVANNAH RIVER ABOVE AUGUSTA AND BETWEEN AUGUSTA AND ANDERSONVILLE, GEORGIA; AND REPORT ON THE PROTECTION OF THE CITY OF AUGUSTA FROM DESTRUCTIVE FLOODS.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., February 16, 1889.

GENERAL: By letter from the Chief of Engineers, dated August 28, 1888, I was informed that there had been assigned to my charge the examination of the "Savannah River above Augusta and between Augusta and Andersonville," required by the river and harbor act of August 11, 1888, with the view of ascertaining whether the said river is worthy of improvement.

On October 17, 1888, I was directed to include in the examination ordered the question of the protection of the city of Augusta from floods. The examination was made under my direction by Mr. George W. Brown, assistant engineer, whose report is appended hereto. Continued high water seriously interfered with the field work, and the completion of the report which I now have the honor to submit has been unavoidably delayed until the present date.

The Savannah River is formed by the junction of the Tugaloo and Keowee (or Seneca) rivers at Andersonville, S. C., and flows in a southeasterly direction to the sea.

The valley through which the Savannah River flows between Andersonville and Augusta has an average width of from one-third to one-half of a mile, beyond which the country is rolling and hilly.

Where the land has not been cleared for cultivation good timber is abundant, the principal varieties being willow, cottonwood, poplar, gum, oak, sycamore, birch, pine, etc.

The banks of the river are, in general, higher than the rest of the valley, and at short intervals ditches have been cut leading from the low grounds of the valley through these banks into the river. The rain-fall is thus conducted rapidly into the river and sudden high freshets are of frequent occurrence.

The principal product of the section of country adjoining the river is cotton, although grain, potatoes, etc., are produced abundantly. The river bottoms from Lockhart's Creek to Trotter's Shoals and from Craft's Ferry to Andersonville are quite fertile, although the crops are often damaged and sometimes almost entirely destroyed by river floods which continually increase both in frequency and magnitude. The soil at other points along the river is rather poor.

The slope of the river between Andersonville and Augusta was carefully determined by barometric observations, checked by computations from observed velocities and cross-sections, and occasionally by spirit levels. With what degree of accuracy these slopes were ascertained it

is not possible to say, but as the height of the river surface at Andersonville obtained by two independent methods agree within a few feet, and as the results obtained at other places by different methods agree very closely with each other, it is thought that the profile presented is approximately correct. It will be observed that it differs very greatly from the results given by Mr. Carson (Appendix I 2, Report of Chief of Engineers, 1879), but his observations were so discordant that very little weight was given to them.

Between Andersonville and the canal locks above Augusta, a distance of 106 miles, the river has a total low-water fall of 400 feet, or an average fall of nearly 4 feet per mile. The stream is greatly obstructed by shoals and ledges of rock and gravel, which render navigation difficult and dangerous. It is navigable by pole boats only, and by them during only a portion of the year. The actual present head of navigation is Petersburg, Ga., although occasional trips are made farther up the stream.

At Petersburg the river receives its largest tributary, the Broad River, a stream which at times brings down a volume of water greater than that flowing in the Savannah itself.

By referring to the profile which accompanies this report it will be seen that the river is divided near Petersburg into two sections, with distinct physical characteristics.

From Petersburg to the Augusta Locks, a distance of 51 miles, the slope is comparatively gentle, the fall between these points being 109 feet, or an average of 2.1 feet per mile. Leaving out the fall in the vicinity of Long Shoals, where the river descends 53 feet in 10½ miles, the average fall for the remaining 40½ miles is less than 18 inches per mile. From Petersburg to Andersonville, a distance of 55 miles, the river is a torrential stream, the total fall between these points being 288 feet, or an average of 5.25 feet per mile. At Trotter's Shoals there is a fall of 74.88 feet in 7 miles, and at several other places falls of over 10 feet per mile occur. On the profile the depth of water shown is that in the tortuous pole-boat channel. This is often only from 12 to 15 feet wide, the rock bottom of the river being bare at other points. The velocity of the currents in these chutes is very great, and any removal of obstructions from the river-bed would only increase this velocity and render up-stream navigation still more difficult than it is at present. It is practicable to satisfactorily improve this portion of the stream for even pole-boat navigation by means of locks and dams only. For a 3-foot navigation there will be required a total lift of 291 feet, which will cost approximately $5,200,000.

Below Petersburg the cost of a similar improvement would be approximately $2,000,000, making a total cost of slackwater navigation from Andersonville to Augusta approximately $7,200,000. To accurately estimate the cost of such an improvement would require a detailed survey of the river, but it is believed that slackwater navigation can not be obtained for a less amount than that given, while it may cost a great deal more. The improvement would, however, permit of steam navigation, which can not be obtained upon any portion of the river in any other manner. Below Petersburg it may be possible, by excavation and the construction of contracting works, to so improve the existing pole-boat channel that such boats may run during a greater part of the year. Mr. Brown estimates that there can be provided an unobstructed pole-boat channel between Augusta and Petersburg, with a minimum depth of 2 feet at all seasons of the year, for $35,725. In

view of past experience upon this stream, it is thought that these estimates are too low. The examination just completed was made when the river was from 1 to 5 feet above its extreme low-water stage, and although great care was exercised, it was not possible to examine in detail all of the obstructions to low-water navigation. Accurate estimates of the cost of such work can be made only after a detailed survey of the river at its extreme low-water stage. Such a survey could be made in one month, did the stage of water permit.

With a view to collecting data relating to the extent of territory to be benefited by the improvement of the river and the amount of commerce and navigation interested in the same, letters were addressed in September to postmasters, boards of trade, and prominent citizens residing near the river requesting general information, statistics, statements of present and prospective demands of commerce, etc. To repeated requests for such information no answers were received. The interest of the community in the proposed improvement may be measured by this lack of action. Such information as it was possible to obtain was collected by my assistant, Mr. Brown, and is contained in his appended report. From the data thus obtained it will be seen that the present amount of down-freight which may reasonably be assumed as tributary to the river between Andersonville and Petersburg, and which would probably be shipped by water were the river navigable by steamboats, is about 29,467 bales of cotton, plus miscellaneous other freight equal to about one-fifth of that amount, or a total annual shipment of an equivalent of 35,360 bales of cotton. Assuming an equal amount of up-freights, which is a very liberal allowance, and then estimating upon the present rail rates, and the cost of an average wagon haul of 12 miles, the total expense of rail and wagon transportation would amount to $116,020 annually. These freights could probably be profitably carried by steam-boats for $64,156 annually, giving $51,864 as the annual value to the community of steam-boat navigation.

As the cost of making the river navigable for steam-boats over this distance will be at least $2,000,000, it is seen that the amount of commerce to be benefited does not now justify that method of improvement.

With the facilities offered by pole-boats only, a narrower section of country would be tributary to the river. Mr. Brown has assumed it to be 75 per cent. of that which would be tributary to the river were steam navigation possible.

Under this assumption, and estimating the up freights at 60 per cent. of the down freights, we should have $50,918 as the total annual freight receipts of pole-boats between Augusta and Petersburg.

To transport an equal amount of freight by rail and wagon would cost $73,796, leaving an annual balance of $22,878 in favor of improved pole-boat navigation.

The figures and estimates just given are based upon statistics contained in the census of 1880, assuming subsequent rates of increase for the whole section tributary to the river proportional to those obtaining in the adjoining counties of South Carolina. By many well-informed persons familiar with the business of the river the estimated pole-boat freights before given are considered too great, an equivalent of 18,950 bales of cotton annually being regarded by them as a liberal estimate, reference being had to existing railroad facilities, etc. The saving due to improved pole-boat navigation being about 91 per cent. of the cost of hauling the same amount of goods to and from the railroad, we have, upon the new basis, $13,796 as a total annual saving due to improved pole-boat navigation.

During the years 1885, 1886, and 1887 the annual pole-boat receipts at Augusta amounted to an equivalent of 4,920 bales of cotton, giving $4,477 as the annual commercial value of the river in its present condition. This amount subtracted from $13,796 gives $9,319 as the net annual saving due to an improved pole-boat channel between Augusta and Petersburg. This capitalized at 6 per cent. gives $155,316.37, the amount which, assuming the foregoing data as correct, could be profitably expended as a purely business investment in the improvement of the river between Petersburg and Augusta in giving a channel navigable by pole-boats, leaving out of consideration the advantages of the river as a competing route in the regulation of freight rates, the value of the commercial development to be expected from the improvement, etc.

In my opinion, however, based upon personal knowledge of the locality and character of the navigation upon the river, the influence of railroads has not been sufficiently considered, even in the smaller of the estimates of the value of pole-boat navigation before given.

Within the last ten years the products of the section of country tributary to the river have increased in amount over 30 per cent., while, with the river in better condition now than it was at the beginning of the decade, river freights have decreased in amount 67.2 per cent., due principally, if not entirely, to the influence of the railroads constructed during that period. For equal wagon-hauls pole-boats, even under favorable circumstances, can not compete with railroads, and the probable effect of an improved pole-boat channel would be to slightly cheapen the cost of transportation, thereby stimulating production along the immediate river valley, without, however, drawing much freight from the railroads or doing much to regulate their freight rates. For these reasons I am of the opinion that the total annual savings resulting from an improved pole-boat navigation would not be more than 50 per cent. of that previously given, or $6,898. This gives the net annual value of improved pole-boat navigation as $2,421, which capitalized at 6 per cent. gives $40,350, the maximum sum which, in my opinion, can now be profitably expended in the improvement of the river. Whether or not the desired improvement can be completed for this amount can not be determined in advance of a detailed survey, which I recommend may be ordered. The survey should extend from Augusta to Petersburg and will cost $750.

PROTECTION OF AUGUSTA FROM DESTRUCTIVE FLOODS.

Such meager records concerning the early condition of the Savannah River as are available show that at the time of the settlement of the river valley the water of the stream was clear; that the river contained many varieties of fish in great numbers, and that floods were rare and of insignificant proportions. With increase of population the forests were rapidly cleared away and large areas of land were brought under cultivation. It is generally recognized that the clearing of forests and the increase in area of tilled land in hilly countries produce injurious meteorological changes and more numerous and more destructive floods. During heavy rains the loose soil upon the bare hill-sides is easily plowed up and small gullies are formed which are rapidly enlarged into deep gorges, through which the water is conveyed into the river, filling it beyond its capacity and causing it to overflow its banks. The gorges or ravines thus formed also bring into the river during heavy rain-falls masses of earth and other debris, which makes the water of the stream turbid, fills up the river-bed, and increases its liability to destructive

overflow. The formation of gullies is further aided in the Savannah Valley by the method of cultivating the land in furrows leading up and down hill instead of in horizontal lines and by the cutting at short intervals of ditches leading from the low valleys through the higher river banks directly into the bed of the stream. Within late years the destruction of the forests has increased at a very rapid rate.

From the census reports it is ascertained that the crops in the valley have increased in amount about 3 per cent. a year for the last ten or twelve years, and it is presumed that the acreage of cleared lands has increased in nearly the same ratio, although information necessary for a definite determination of this question is wanting. Very little accurate data relating to the earlier river floods could be collected. From 1881 to 1888, inclusive, quite complete notes of the rain-fall and corresponding river heights at Augusta were obtained. These are presented in Appendix 4. From readings of the river gauge at Augusta I have plotted curves showing the daily heights of the river at that point from 1880 to 1888, inclusive (sheet E). The zero of the gauge is supposed to indicate the low water of 1835, and from railroad levels is ascertained to be 129.93 feet above mean low water at Charleston, S. C. Reference to this diagram of river heights shows that while freshets are liable to occur at any time the average height of the river during the first few months of the year is greater than during any other corresponding period of time. Shortly after the settlement of the Savannah River valley, the water of the river became yellow and freshets began to appear, culminating in the flood of 1796, known as the Yazoo freshet. This flood carried away the bridge across the Savannah River at Augusta, and caused great damage to property. The next destructive flood is what is known as the Harrison freshet, which occurred on May 28, 1840. The whole city of Augusta was inundated, the water reaching a height of 37.5 feet on the river gauge. In 1852 and in 1865 destructive floods again occurred, the river reaching on August 29, 1852, a height of 36.8 feet, and on January 11, 1865, a height of 36.4 feet. Since 1865 portions of the city have been many times submerged, but it was not until 1887 that any serious damage was done. On July 29, 1887, the rain-fall was 4.18 inches. The river rose rapidly, reaching its maximum height of 34.5 feet on July 31. A considerable portion of the city was inundated, the water standing in places 10 feet deep. The corn crop in the bottom lands below Augusta was almost entirely destroyed, as was also the rice crop near the city of Savannah.

In 1888 occurred a flood, the most destructive to life and property ever known in the history of the Savannah River.

From the 1st to the 9th of September, 1.98 inches of rain had fallen. The ground had become thoroughly saturated. Beginning at 3 a. m. on the 9th and ending at 6 a. m. on the 10th, 3.71 inches fell. Six hours after the rain recommenced, on the 9th, the river began to rise at Augusta, and seventeen hours after the rain had ceased falling, the river was at its highest, viz., 38.7 feet. The rain causing this freshet fell mostly in regions not very remote from Augusta. The speed with which the river rose after the commencement of the heavy rains shows this. It was observed, also, as I have stated before, that the bulk of the water passing Petersburgh was from the Broad rather than from the Savannah. For fifty-nine hours at Augusta the water was above 32 feet, or the height at which the river seriously overflows its banks through the city.—(G. W. B.)

From the precipitation charts which I submit it will be seen that while the normal precipitation in the Savannah River basin for the month of September is only from 2 to 4 inches, during September, 1888, more than 12 inches of rain fell over the entire upper portion of the Savannah River water-shed. At several points within this water-shed

from 12 to 16 inches of rain fell during that month, and at some points from 4 to 8 inches fell within twenty-four hours.

During the freshet of September, 1888, the water reached its extreme height early in the morning of the 11th, reaching the highest point known, 38.7 feet. At this height the water covered the entire city north and east of the first and second levels of the canal, even crossing the latter to a very limited extent. The water was from 1 to 12 feet deep all over this ground, running along streets at very high velocities toward the south and east. The freshet slope in the river along the city was about 6 feet in 2½ miles, and across the city from the northwest to the southeast corners was 13½ feet. A break occurred in the third-level canal banks on Tenth street which let large volumes of water into the city at that point, tearing away houses, etc. The banks of this portion of the canal were built as levees, but only to the height of about 40 feet. At the locks the water poured over the gates, and also lower down it flowed from the river some 6 or 8 feet deep over the canal banks. At about 2 miles below the locks, where the heavy fall of the river had taken the flood level below the tow-path of the canal, breaks began to occur. In the next 2 miles were about three-fourths of a mile of breaks, many of them in very high banks. By these breaks some 16 or 18 mills and factories, using some 7,500 horse-power, were stopped about three and one-half months, until the breaks could be repaired. The streets of the city of Augusta were in many places very badly torn up, causing numerous breaks in water-mains and sewers. The entire damage to the city, the larger portion of which was to private property, has been estimated at 5 per cent. of the assessed valuation of personal and real estate, or about $2,000,000.—(G. W. B.)

With the view of obtaining data for an approximate determination of the flood discharge of the river at Augusta, I directed my assistant, Mr. George W. Brown, to carefully establish the flood slopes from such marks as were well defined, and to obtain cross-sections of the river at its various stages. Through the courtesy of Mr. A. J. Twiggs, civil engineer, we were able to check the volume of discharge computed from data thus obtained by that based on velocity observations taken by him when the flood was at its height. While none of these determinations are accurate, they are presumed to give a close enough approximation to the actual discharge to enable the question of flood protection to be intelligently considered.

THE DISCHARGE OF THE RIVER AT HEIGHTS OF 10.4 FEET AND 24.3 FEET.

Velocities were obtained by loaded rods. Mean velocities were deduced from observed rod velocities by the following formula:

$V_m = V_r [1 - 0.116 (\sqrt{D} - 0.1)$, in which
V_m=mean velocity in the vertical.
V_r=observed rod velocity.

$$D = \frac{\text{Depth of water minus immersion of rod.}}{\text{Depth of water.}}$$

This formula of Mr. Francis was deduced by him from observations in which the value of D was very small, the channel being an artificial rectangular one. Such conditions were not obtainable in the channel of the Savannah River, but as the formula has been found to give very accurate results with a rod immersion of only one-third the depth of water, it was used without change. A few experiments were however made with rods of various depths of immersion, with the object of determining a correction to be applied to the formula when the value of D is great.

The following values, thus determined, were substituted for 0.1 in the preceding formula:

When $\frac{l}{d}$ equals	substitute for −0.1
0.9	−0.10
0.8	−0.05
0.7	−0.00
0.6	+0.05
0.5	+0.10
0.4	+0.15

(l = length of rod float, and d = depth of water.)

Discharges obtained by the foregoing methods of reduction of rod velocities agree very closely, as will be seen from the horizontal curves of mean velocity on sheet I herewith.

The flood discharge of the river was computed, as I have before stated, by using both measured velocities and those determined from the hydraulic mean radius and observed flood slope. It was impossible from existing flood marks to determine the flood slopes with great nicety, and as the observed velocities were those measured at the surface under widely varying conditions and under many difficulties, it is doubtful whether the discharge obtained in that manner is more than a reasonably close approximation to the truth. The discharge obtained by both of these methods is that of the river at about its maximum height.

The maximum velocity and discharge occur before a flood reaches its highest point, but for my purpose I have assumed the discharge computed as before described as the maximum discharge during the flood of 1888.

The discharge of the river under various conditions and at varying gauge heights is shown graphically on sheet II.

The detailed methods of obtaining these discharges are given by Mr. Brown as follows:

The flow of the river I have divided into three parts: That which passed through the channel, considering this bounded on the south by a vertical plane at the south side of Bay street, and on the north by a vertical plane from the top of the immediate banks of the river, giving a channel 990 feet wide above the banks; that which passed over the South Carolina Valley between the river and the bluff; and that passing through the city. This last item is made up as follows: Water which passed across section No. 4 between the northeast corner of Broad and Fifteenth streets and the canal bank near the bridge on Fifteenth street; that which passed through Fourteenth, Thirteenth, Twelfth, and Eleventh from Jones to Broad streets; that which passed along Jones from Eleventh to Tenth streets and along Tenth from Reynolds to Jones; and that which passed through Macarton from river to Jones. This brings us down to section No. 5½, the range over which soundings were taken and discharges computed. In order to check these total discharges of the river I have made computations also over section No. 14½, or that part of it between the south side of Bay street and the bridge, under the lower railway bridge, along the railway from this bridge to the main highway, and along this highway to the bluffs. For this section there must be added the water which passed into the city from the river and Reynolds street to Broad, along Ninth, Eighth, Seventh, Sixth, and Fifth streets, and along Reynolds from Fifth to Fourth streets. For the discharge across Fifteenth street I took the full section between the north side of Broad and the canal bank at a velocity depending on the slope, except in the case of Hawk's Gully, where I used a velocity some 12 per cent. greater, computed from Mr. Twiggs's observations there. This section was practically free from obstructions. The remainder of the discharge through the city was computed along a line where the streets are well lined with buildings close to the street. I estimated that enough water passed through blocks to make the average for the full streets equal to the maximum surface velocities given by computations, from section, wetted perimeter, and slope.

DISCHARGE OF SAVANNAH RIVER, GA., AT FRESHET OF SEPTEMBER, 1888.

1888. River gauge 38.7 feet. Estimated at line of section No. 5½.

[Discharge in cubic feet per second.]

River channel 990 feet wide from south side of Bay street	212,400
Through the city above Ninth street	39,000
South Carolina shore	49,500
Total	300,900

CONDITIONS IN CHANNEL.

Maximum width = 990 feet; maximum depth = 39 feet; mean depth = 29.6 feet
Available cross-section, 29,300 square feet; fall per mile, 2.3 feet.
Mean velocity taken at 7.2 feet per second. (Mr. Twiggs's surface velocity = 8.5 feet per second below the bridge is probably slightly greater than at this point. 8.5 by 86 per cent = 7.31.)

CONDITIONS ON SOUTH CAROLINA SHORE.

Maximum width at section 1,630 feet; maximum depth, 12 feet (except a narrow place where it is 18 feet); mean depth, 9.2 feet; cross-section, 15,000 square feet; fall per mile, 1.33 feet.
Mean velocity, 3.3 feet per second. (Computations from slope and section would give $V_m = 4.92$; but considering the character of the ground and obstruction of trees, etc., this is perhaps too large by more than one-third.)

DISCHARGE OF SAVANNAH RIVER, GEORGIA, AT FRESHET OF SEPTEMBER, 1888.

River gauge, 38.7 feet. Estimated at line of section No. 14½.

[Discharge in cubic feet per second.]

Under railroad bridge on Sixth street	195,260
Through city, at and above Sixth street	41,155
Through culvert, under Carolina Railroad	5,500
Over same road and through miscellaneous breaks	10,000
Over highway	45,915
Total	297,830

CONDITIONS IN CHANNEL.

Width of river, under bridge, 983 feet. Maximum depth, 38.8 feet. Mean depth, 27.8 feet. Cross-section under bridge, 27,327 square feet. (Less section of piers, 1,000 square feet by 1⅓=1,333 square feet, leaving available section about 26,000 square feet.) Observed velocity below, 8.5 feet per second. 8.5 by 86 percent. =7.31 feet, but the water was 3 feet higher than the bottom of the bridge, which gave it at that point a 3-foot head, and increased the mean velocity 0.20 foot per second, giving a mean velocity of 7.51 feet.

CONDITIONS UNDER RAILROAD CULVERT.

Width of culvert, 180 feet. Maximum depth, 8 feet. Mean depth, 6½ feet. Cross-section, excluding piles, 1,100 square feet. Observed velocity reduced and increased by a head of 3 or 4 feet gives a mean velocity of 5 feet.

CONDITIONS OVER RAILROAD ON SOUTH CAROLINA SHORE.

Length, about 1,000 to 1,200 feet. Mean depth, 1 foot.
Several washouts increased the cross-section to about 2,000 square feet, and something of an overpour must have had a mean velocity of at least 5 feet.

Width from railroad, 1,040 feet. Maximum depth, 12 feet. Mean depth, 8.83 feet. Road is reasonably clear and is about 2 feet above ground on either side. Mean velocity of 5 feet per second is none too large.

This determination of discharge practically checks the determination at the gauging range higher up. The greater discharge should be taken as the flood discharge of the river, say 300,000 cubic feet per second, with gauge-reading of 38.7 feet.

From these data I have constructed and submit herewith a diagram showing graphically the heights of the river; areas of cross-sections of river-bed and the Carolina valley; mean velocities in feet per second of the current in both places, and the separate and total discharges at the heights at which the river was gauged, and at the freshet height.

Connecting the points of determined mean velocities by a curve, with reference to the changing conditions, and projecting the curve beyond for only slightly greater heights, we have practically all mean velocities of the river, with considerable accuracy, between, say, 5 feet of the gauge and any height which there is the least liability of being reached by any freshet. About the curve of velocities over the South Carolina valley, there is, of course, some uncertainty. One point, however, is fairly established. Its lower limit is also determined by the point at which the river overflows its banks, which may be taken roughly at about 35 feet. From the one point we may draw a curve representing mean velocities at higher levels, and make it certainly large enough by making its ratio of increase equal the ratio of increase in the main channel just below the freshet height of 1888. Curves, representing the sections of the river and valley, are drawn from computations of sections at a large number of heights, and above, say 4 feet, may be taken as exact. Discharges are then computed from the values given by these two curves, and two discharge-curves, representing the discharges at various heights, are drawn. Another discharge curve is drawn, representing the sum of the discharges through the channel, over the South Carolina valley, and through the city. This represents discharges under present condition. A final discharge-curve is constructed representing quantities which will be discharged by the channel and valley to the north of the south side of Bay street. This represents a condition in which the waters are kept out of the city as by levees. In these curves the ordinates represent the heights of the river by the gauge, and the abscissas the discharge of the river in cubic feet per second. By comparing the discharges which would be given to the north of a levee on Bay street, with that under present conditions it will be seen that had the water of the last freshet been kept from the city it would have increased its height only about 16 inches.

The discharge of the river at various heights will show the magnitude of a Savannah River freshet. From this diagram the discharges for various heights are given in the following table:

Height.	Cubic feet per second.	Remarks.
5 feet	2,000	About lowest water of summer.
6 feet	3,200	
8 feet	6,200	
10 feet	10,400	About the ordinary winter flow.
15 feet	21,700	
20 feet	39,000	
25 feet	59,600	
30 feet	89,600	
32 feet	110,000	
34 feet	136,000	Height of freshet 1864.
34.5 feet	143,000	Height of freshet 1887.
36 feet	165,000	
36.4 feet	202,000	Height of freshet 1865.
36.8 feet	220,000	Height of freshet 1852.
37.5 feet	253,000	Height of freshet 1840.
38.7 feet	300,000	Height of freshet 1888.
39 feet	320,000	
40 feet	370,000	

NOTE.—The discharges given in the table for low-water stages of the river are probably too small. The river was gauged at the canal locks in 1869, when the water was at an "extremely low stage," and the discharge found to be 2,575 cubic feet per second. Another determination gave a distance of 2,400 cubic feet per second with a gauge-reading of 4.2 feet at Augusta. It is probable that the discharge for a gauge-reading of 5 feet is not less than 2,500 cubic feet per second.—(O. M. C.)

Although the discharge at Augusta of 300,000 cubic feet per second at and during the freshet of September, 1888, is the greatest known, yet under the existing conditions in the river valley previously described, and with phenomenally heavy rain-falls this might be exceeded, and in considering the question of future protection of the city of Augusta a reasonable factor of safety should be allowed. The area of the Savannah watershed above Augusta is not more than 7,500 square miles. If the ground were thoroughly saturated the discharge per second at the city of Augusta might approximate to the rainfall per second over the entire watershed. While rain-falls of 8 inches in twenty-four hours sometimes occur over limited areas it is not probable that an average fall of 2 inches in twenty-four hours over the entire watershed will ever be exceeded. Assuming a rain-fall of this magnitude we have a corresponding discharge of 403,333 cubic feet per second. Under the conditions of a thorough saturation of the ground the river will probably not stand below 25 feet on the gauge, or have a discharge per second less than 60,000 cubic feet. This added to the previously computed discharge would give a total maximum discharge of 463,333 cubic feet per second, which should be provided for in any scheme of protection against overflow. Mr. Brown, by using too large an area of watershed and a smaller ordinary discharge arrives at practically the same result.

It does not lie within the power of man to remove the causes of the destructive floods in the Savannah River Valley, although their evil effects might be lessened by a more careful and rational method of tillage, and by a partial reforestation of the hill sides. Complete relief must, however, be secured by controlling the floods. Many methods of doing this have been suggested, some of which have for their object the protection of the city of Augusta only, others that of the protection of the whole river valley below that city as well.

The principal methods proposed for protecting the city of Augusta from destructive floods are the following:

Deepening and rectifying the river channel below Augusta to such an extent as to enable it to discharge the flood-water without overflow.

Providing additional outlets for the flood-water by extending the present canal below the city or by cutting a canal on the Georgia or South Carolina side of the river.

Confining the river to its bed by levees.

Impounding the flood waters in restraining-reservoirs in the valley of the upper river so as to regulate the flood discharge.

The total fall of the Savannah River at low water from Augusta to the sea, a distance of about 300 miles, is approximately 134 feet, or $5\frac{1}{3}$ inches per mile. The low-water fall of the river from the foot of the rapids at Augusta to Sand Bar Ferry, a distance by water of 8 miles, was found by Mr. Brown to be about 2 feet, or 3 inches per mile. On page 1102 of the Annual Report of the Chief of Engineers for 1881 I find the fall for the next 10 miles given as about 24 inches per mile, and for the next 27 miles as about 12 inches per mile. These slopes were determined from points on the Port Royal and Augusta Railway, whose elevations were only approximately known, and no river gauge readings were taken during the determination. The slopes are not reliable, but in the absence of any better information are assumed to be correct.

The freshet slope of the river in September, 1888, in front of the city of Augusta was a little more than 2 feet per mile, with mean velocities of less than 7.5 feet per second.

The character of the soil below Augusta is such that it would be impossible to maintain an unrevetted channel with mean current veloci-

ties of greater than from 6 to 8 feet per second even if the topography of the country permitted the obtaining of any desired fall.

The maximum discharge at Augusta during the freshet of September, 1888, was found to be 300,000 cubic feet per second, and the maximum flood discharge which it has been seen should be provided for in any scheme of flood protection is 464,000 cubic feet per second.

To void this volume of water with a mean velocity of 8 feet per second would require a channel area of 58,000 square feet, or a width of about 1,760 feet with a mean depth of 33 feet.

By referring to the charts submitted it will be seen that for the most economical construction of such a channel no deepening should be done above Ninth street but it is probable that the channel would have to be enlarged as far up as Hawk's Gully, or perhaps Rae's Creek.

The low-water slope of the river for about 8 miles below Augusta is, as we have seen, very small, and flood water can not be conveyed away from the city in the excavated channel, unless the enlargement is carried farther down the river, and it is probable that advantage would have to be taken of the total fall of the river within at least 20 miles of the city.

Assuming the excavation to begin at Ninth street and extend, with a uniform slope, to a point 20 miles below, the average depth of the cut would be about 30 feet, and the material to be excavated would amount to, roughly, 207,000,000 cubic yards. The cubic contents of the present channel are not more than 95,000,000 cubic yards, leaving an excavation of 112,000,000 cubic yards to be provided for, which at 25 cents per cubic yard would amount to $28,000,000. On the basis of the flood discharge of September, 1888, this estimate would be reduced to $9,750,000. In these estimates nothing is allowed for property which would be destroyed and for land which would be cut away or covered with excavated material. By raising the river-banks with the excavated material the area of the cut would be diminished, but its length could not be materially shortened without backwater entering the city, unless levees were built from the river across the adjoining lowlands.

By conducting the river in a straight line from the city to a point 20 miles below, a greater fall could be obtained and less excavation would be required. The cost would however be increased, as no use could then be made of the present channel. A further objection to this scheme is that it would render the river, near Augusta, unnavigable.

The question of providing additional outlets for the flood water by extending the present canal below the city or by cutting a canal on the Georgia or South Carolina side of the river has been considered.

By referring to the diagram it will be seen that at 32 feet, the height at which the water begins to damage the city, a discharge of only about 110,000 feet per second can be obtained through the present channel. The freshet discharge at 38.7 feet was, however, 300,000 cubic feet, leaving a surplus of 190,000 cubic feet per second to be accommodated in other channels. A uniform channel to contain this, reaching the river within 10 miles below Augusta, would have the same total fall which now exists in the river. Upon the Carolina side a channel entering 10 miles below would be at least 12 miles long which would decrease its fall per mile about 16 per cent. The most economical dimensions of such would be 900 feet wide and 30 feet deep. This would give a mean velocity of 7 feet or a total discharge of 189,000 cubic feet per second. The contents of such a cut, assuming the ground to be low (it is in many places quite elevated), would be about 62,000,000 cubic yards, and the cost at 16 cents $9,920,000. Such a cut entering just above Sand Bar Ferry would give a fall per mile of only half as great, would be 6 miles long, and, to carry this water, could not be less than 1,280 feet wide. This at the same rates would mean an outlay of $7,200,000. Reaching the river 10 miles below the city, on the Georgia shore, this surplus water would require a channel, commencing above Hawk's Gully and connecting with the river at the mouth of a large creek just above "New Savannah Bluff," 8 miles long in a direct line. The

total fall available would require a cut 815 feet wide and 30 feet deep, which could be constructed at a cost, considering the low ground passed over, of about $6,000,000. This, however, condemns a strip of ground 1,000 feet wide and at least 2 miles long through the city of Augusta. But whatever cuts may be made to carry the water either wholly or in part, they must enter the river at such a point that the fall below may be sufficient to give a velocity great enough to carry off the entire flow of the river in a single channel. If such a velocity can not be obtained below the point of junction, the waters will rise, decrease the fall in the separate branches and consequently the velocity, and cause a rise back into the undivided river. At no point within 10 miles of the city could such cuts enter and not cause nearly the same rise which any given discharge gives under existing conditions. It is even more probable that 15 miles is not too far below the city for cuts to enter in order to reach a fall per mile which would give no backwater.—(G. W. B.)

Although computations have been based upon the flood discharge of September, 1888, which is only about 54 per cent. of that which can be safely assumed, and upon a length of canal of only 8 miles, which is also too small, the cost has been found to be about $6,000,000. By raising the banks of this canal its cost could be considerably reduced, but not to such an extent as to entitle this scheme of protection to further consideration.

For the protection of Augusta by levees it is necessary that the entire city should be inclosed. The proposed location of such a levee is shown on a map of the city, which is transmitted with this report. The canal banks above the city should be so raised and strengthened as to prevent overflow. The length of the proposed levee is about 30,000 feet. It begins at the canal bank just above the Algernon Mill and extends to a point in the river bank about 1,600 feet above Hawk's Gully; thence it extends along the river bank to a point about 800 feet below East Boundary street; thence in a southerly direction 600 feet; thence back to East Boundary street and along it to the Port Royal and Augusta Railway track; thence southwest until south of the Georgia Chemical Works; thence west to high ground.

Assuming a maximum flood discharge of 464,000 cubic feet per second, it will be seen by referring to the diagram of river discharges that were the river prevented by a levee from entering the city it would rise at Fifth street to a height of 44.2 feet on the river gauge. The crest of the proposed levee has at that point an elevation of 46 feet, which would permit without overflow a discharge 16 per cent. greater than that given. Assuming the freshet slope of the river at a height of 46 feet to be 50 per cent. greater than that in September, 1888, we have the following levee heights:

Location.	Elevation above 0 of river gauge.
	Feet.
Canal bank	53.5
Hawk's Gully	51.5
Fourth street	48.3
Sixth street	46.6
Third street	44.9
East Boundary	43.6
Greene street	42.6
South Boundary	41.0
South of city	41.0

Typical cross-sections of the proposed levee are shown on sheet K, and the detailed method of construction is given in the following extract from Mr. Brown's report:

The levee should have an average top width of 15 feet from the canal bank to about Fourteenth street, being greater at salient points and slightly less where parallel to the channel. Below Fourteenth street to extreme eastern angle a width of 12 feet would be sufficient. Along South Boundary a width of 12 feet, but of different material; along the railroad the required width of 14 feet, and along the remaining portion 10 feet. Such a levee, to be built in the most economical manner consistent with unquestionable permanency, would have a cross-section along the river of the form shown on the sketch herewith.

Slopes are limited by the available space and in some places are steeper than might otherwise be advisable. Slopes of 1 on 1½ on both sides are safe. Both slopes should be very carefully and closely covered with stone; exposed stones extending at least 1½ feet into bank upon a bed of finely broken stone about 5 inches thick. Suitable stone is found near, with a quarry fracture which would give excellent faces and joints without dressing. This stone facing should extend to about low-water mark of river, or to 5 feet on gauge, where it would butt against and closely join a line of piles, each at least 12 inches in diameter and 15 feet long, driven closely together, with slabs driven between at the back. On the back side of the levee the stone covering should rest against heavier stone footings 3 feet below the natural surface. The body of such a dike would be made of materials taken from the bank in preparing the front slope. Where such materials are of sand or any loose materials which water will penetrate, a core wall of brick, 8 inches thick, should be built on footings 2 feet below the natural surface and extending to about 1 foot below grade. Such a wall should be carefully laid up in cement. All materials disturbed should be carefully rammed and thoroughly wetted before stone covering is put on. For the first 2,500 feet from the north end, or until the outer toe of the wall comes within 100 feet of the river, the front toe may safely terminate on broad stone footings 10 feet below the natural surface. In crossing present tail-races of the King and Sibley mills, which should be closed, stone should extend to about 5 feet and terminate on piles as before. Upon the river side of this, between the Algernon Mill and Hawk's Gully, a canal cut for combined tail-races should lead along levee. The stone covering on back of levee extending to piles at bottom of canal would form the side of the canal. From the second angle after leaving the river (or at station 17,600 feet) to the end, earth only would be used with slopes of 1 on 2 on both sides, the whole being thoroughly sodded with Bermuda grass. The reason for using the railroad grade at the south is, that as the tracks must be raised above a freshet line, no property need be condemned and the work can be done more economically to the public and the railroad company. A core wall should be used in this earth bank where needed, the same as before.

The cost of such a work has been carefully computed from station to station from profiles. The figures given are safe and reasonable, all the circumstances being considered.

Filling, 610,000 cubic yards, average rate 22 cents	$134,200
Stone, 160,000 cubic yards, average rate $2	320,000
Piles, 15,500 (including slab work), $2	31,100
Bricks, two-thirds of length, at 12½ per square foot	46,000
Total for levee, excluding bulk-heads	531,300

(G. W. B.)

The inclosure of the city of Augusta by levees would necessitate changes in the present system of sewerage, in the regulation of the water power, in the grades of the railroads and highways, etc.

Detailed information concerning all of the required changes was collected, and the following estimates are based for the most part upon accurate instrumental examinations:

Estimates of cost.

Level, complete, excluding bulk-heads	$531,300
Bulk-heads	95,000
Collecting basin for sewerage	26,000
Intercepting sewers	18,750
Second and third levels of canal to south levee	24,700
Canal from Algernon Mill to Hawk's Gully	56,044
New highway bridges across second and third levels	25,500

Grading street approaches	$4,500
City wharves and bridge	10,000
Raising railroad bridge	15,000
Raising passenger tracks	452,000
Miscellaneous damages to freight yards, depots, etc	130,000
Raising trestles, etc., in South Carolina	9,000
Damage to private property in Georgia	50,000
Damage to private property in South Carolina	2,000
Total	1,4 9,794
Add for engineering, about 3½ per cent	50,206
Total	1,500,000

While perfect protection for the city of Augusta can be afforded by levees at a cost of only 75 per cent. of the damage caused by the freshet of 1888, no protection whatever would be afforded to the plantations along the river, the damage to which exceeded in value that to the city of Augusta. Moreover, levees restrict the growth of a city, and are only desirable as a method of protection against floods when other means are not obtainable at a reasonable cost.

With the view of an approximate determination of the practicability of controlling the floods of the Savannah River Valley by suitably located restraining reservoirs. Mr. Brown was instructed to collect during the examination of the upper river as much data as possible concerning the topographical features of the valley. It was impossible, with the meager funds available, to extend the examination beyond the main river or beyond Andersonville. A map and profile of the river from Augusta to Andersonville are submitted with this report.

During the freshet of 1888 the river stood at Augusta for fifty-nine hours above 32 feet, or the point at which dangerous overflow takes place.

By referring to the diagram of river discharges it will be seen that the mean discharge during that time was 206,500 cubic feet per second. Deducting the river discharge for a height of 32 feet we have 20,500,000,000 cubic feet as the volume which should have been impounded to properly control the freshet of 1888. But we have seen that freshets of greater magnitude are liable to occur. To afford perfect protection for the city against future inundation provision must be made for impounding 60 per cent. greater volume of water, or about 32,800,000,000 cubic feet.

By referring to the profile of the river above Augusta it will be seen that a dam extending across the valley near the head of Long Shoals, and 50 feet in height would, provide a reservoir area of about 12,250,-000,000 cubic feet, which is 60 per cent. of the surplus flood water of 1888, and about 38 per cent. of the assumed maximum surplus volume.

Such a dam could be built for about $500,000. Where navigation is not interfered with a much cheaper method of construction could be adopted. It is probable that better protection could be afforded at a less cost by damming some of the tributaries of the Savannah River, such as Little River of Georgia, Little River of South Carolina, Broad River of Georgia, Big Beaver Dam Creek, Keowee River, Tugaloo River, etc., and that for the sum necessary to protect the city of Augusta by levees the whole river valley could be protected against destructive inundations.

The question of the absolute practicability and cost of the reservoir system of flood protection can however be determined only by a series of extensive surveys for which neither time nor funds were available. Such surveys as are necessary for the purpose could be made in four months at a cost or $5,000.

Summing up, we see that of all the methods of flood protection proposed only two deserve serious consideration, viz, that by levees and that by reservoirs. The practicability and cost of the former system have been determined; for a report upon the latter system sufficient information is not yet available.

Should the city remain in its present unprotected condition the destruction ordinarily caused by freshets could be greatly lessened were it possible to predict with accuracy the effect upon the river of rain-falls of various magnitude occurring in different portions of the water-shed, so that preparations could be made to receive the flood.

Predictions of this character to be of much value should be based upon daily observations of rain-fall and river heights intelligently made and extending over a period of several years.

In concluding my report I desire to invite attention to the efficient services rendered both in the field and in the office by Mr. George W. Brown, the assistant engineer in charge of the field work of the examination. I desire also to express my obligations to Mr. A. H. Davidson, Mr. A. J. Twiggs, and other citizens of Augusta and vicinity for valuable information.

The following appendices and maps accompany this report:

APPENDICES.

1. Report of Mr. George W. Brown, assistant engineer.
2. Statement of commerce passing through canal locks at Augusta.
3. Crop reports of certain counties in Georgia and South Carolina.
4. Record of rain-fall and river heights at Augusta in 1881–1888.

MAPS.

A. Map of Savannah River from Augusta, Ga., to Andersonville, S. C. (in five sheets).
B. Profile of Savannah River from Augusta Ga., to Andersonville, S. C.
C. Map of Savannah River Valley from canal locks to Sand Bar Ferry (in four sheets).
D. Map of the city of Augusta.*
E. Diagram of river heights at Augusta from 1880 to 1888.
F. Precipitation chart for September, 1888.
G. Chart of normal precipitation for September for eighteen years (1870 to 1888).
H. Diagram of cross-sections, mean velocities, and discharges of Savannah River.
I. Cross-sections of Savannah River at Augusta (in two sheets).
K. Sections of proposed levee.

Respectfully submitted.

O. M. CARTER,
First Lieut., Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. GEORGE W. BROWN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., February 11, 1889.

SIR: I have the honor to submit the following reports of the examination of the Savannah River, between Augusta, Ga., and Andersonville, S. C, and an examination in and about the city of Augusta, Ga., with reference to protecting that city from destructive inundations, made in accordance with the following instructions:

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., November 6, 1888.

SIR: Having reached Augusta, Ga., you will proceed to make an examination of the Savannah River, between that point and Andersonville, S. C. You will note especi-

* Omitted; printed in House Ex. Doc. No. 213, Fifty-first Congress, first session.

ally the height and character of the river banks, the size and variety of trees and brush, the length and depth of pools and shoals, the variations in water level at different points, the nature of the bottom and location, nature and magnitude of existing obstructions to navigation with a view to determining the means and probable cost of removing them so as to secure a channel practicable at all seasons of the year for such boats as may be necessary to carry the river's commerce. You will also collect statistics, as much in detail as possible, concerning the character and amount of commerce and navigation, prospective as well as present, interested in the proposed improvement.

The high and low water slopes of the river will be determined barometrically.

Near Andersonville, Trotter's Shoals, and Augusta cross-sections of the river will be carefully determined for use in discharge measurements. When practicable these sections will be continued to the high-water mark by leveling, and permanent bench marks established. The velocity measurements will be made by means of loaded rods, surface or double floats. At the principal shoals where rock excavation or other works of improvement may be required detailed sketches will be made, and the river slope from the pool above to that below determined with a hand level. A map showing the results of the examination will be plotted on a scale of from 1 to 2 inches to a mile.

In connection with this examination the question of the protection of the city of Augusta, Ga., from destructive inundations will be considered. An approximate topographical map of the river valley from the city to the canal locks will be compiled. The low-water, ordinary, and maximum flood discharges of the river will be obtained as accurately as possible, the slope of the water surface at all of these stages being determined by instrumental level, if any flood marks are remaining, for the determination of the first. Cross-sections of the river, during extreme floods, at various points between the city and the canal locks will be taken, and you will determine as accurately as possible the height to which the banks of the present channel must be raised to void, without overflow, the volume of flood water; whether it is practicable to raise the banks to that height; and if so, the approximate cost, and if not, whether there are any other feasible means of protecting the city of Augusta from overflow, as by enlarging the river section by excavations on the South Carolina bank, etc.

You will compile a brief history of all of the great floods of the Savannah River, giving their heights, duration, date of occurrence, etc., and you will obtain a record of the daily river-gauge readings at Augusta from 1880 to the present time, with the corresponding rain-fall in the Savannah basin.

In view of the detailed verbal orders given to you no further written instructions are considered necessary.

* * * * * * *

Very respectfully, your obedient servant,

O. M. CARTER,
First Lieut., Corps of Engineers.

Mr. G. W. BROWN,
Assistant Engineer.

While waiting for a suitable low stage of water upon the Upper Savannah, I was engaged upon field and office work in the city of Augusta, Ga., from November 7, to December 9, 1888. Upon December 10, 1888, the examination of the upper river was begun, and completed upon the 23d. For this examination I procured the services of two of the most experienced and intelligent pilots on that part of the river, with a boat and a crew of six experienced boatmen. The boat used was the ordinary pole-boat used in freighting. It was 85 feet long over all, about 7 feet wide and drew 6 inches.

The major portion of the examination was made on the up trip. Sufficient time was given to take very full notes; the boat at best moving very slowly.

The instruments used were a transit with compass and level, a hand level, and an aneroid barometer.

Magnetic bearings were taken from point to point along the entire length of the river. Distances between these points were estimated, and were occasionally checked by stadia measurements. Distances were also carefully compared with those given on maps, at previous examinations, and by the pilots and others acquainted with the river. The distances which seemed the most probable I have adopted and shown on the map of the river which I present herewith. At the principal shoals the fall was determined with a spirit-level, except in the case of Trotter's Shoals which had been determined in the same manner by Mr. Carson (see Report of Chief of Engineers, U. S. A., 1879, Part 1, page 757). The fall at some few shoals was estimated by comparison with others which had been measured.

The aneroid barometer was set at 82° to agree with the United States Signal-Service standard at Savannah, corrected for error and temperature only. At Augusta it was

compared with standard both before and after the examination, and was found to be practically correct. Upon the up trip the barometer was read something oftener than once every 2 miles on an average, and on the down trip about once a mile, or every fifteen minutes. From the United States signal offices at Augusta and Atlanta, the barometric pressures were obtained for three readings daily during that time, corrected for error and temperature and reduced to sea level. From the same source charts were obtained giving curves of equal barometric pressure for the adjacent States during the time taken by the examination. From these data barometric curves were constructed for both Augusta and Atlanta for each day, and another set of curves for each day, bearing a relation to these and depending upon what part of the river they were for and the general direction of isobarometric curves for that day. From these mean curves the sea-level pressure was scaled off for the time and place of each aneroid reading, and the difference between local and sea-level pressure being reduced to feet by Williamson's tables gave the elevation of the aneroid above sea level. No temperature correction was applied to the aneroid, it having been compensated for temperature by the maker. Many of the individual results obtained were quite discordant, but by combining the determinations of the up trip with those of the down, the mean, while of course somewhat unsatisfactory, may be fairly considered of value.

An approximation to the fall was made from the velocity of the current. Upon the up trip velocities were taken at a number of places by floats, and at other places estimated by comparison. Upon the down trip all velocities were again taken, directly in the following manner:

The boat was run in the quickest water of the channel; the velocity of the boat through the water, propelled by two sweeps, was determined under each change of circumstances by comparison with surface floats; its total velocity down the river was determined from the time taken to pass between known points. The difference between these velocities gave the maximum surface velocity of the current. By taking the time above and below rapids, and at every place I was able to locate on my maps, I was able to get the velocities at nearly every pool and eddy, as well as upon some of the shoals.

Upon the down trip soundings were taken and the nature of the bottom noted. Widths of river were also taken at a number of places.

From these data the fall was approximated by using the following formula, given in another form by Trautwine:

$$F = \frac{p\,v^2}{2\,A}$$ in which

F = fall in feet per mile,
A = cross-section of water-way in square feet,
p = wetted perimeter in feet,
v = mean velocity in feet per second.

The mean velocity was also approximated by multiplying the greatest surface velocity by a number depending upon it (given also by Trautwine), essentially as follows:

For values of V_1 in feet per second, multiply by

1	0.77
1½	.78
2	.79
2⅔	.80
3⅓	.81
4	.82
5	.83
6	.84
7	.85
8⅓	.86
10	.87
11⅔	.88

The velocities found varied from 1.8 feet to 8 feet per second. On shoals and rapids even approximate measurement was impossible, but the velocities were very great.

These elevations, approximated from the velocity added to those given by the level, agree well with the mean of the barometric elevations. At Andersonville, S. C., the results by two methods only differ by some 7 feet. On the profile of the river, which I present herewith, the elevations given are those determined from weighted means of the two methods, except between The Locks and Sand Bar Ferry, where the elevations are instrumental, being referred directly to mean low water at Charleston, S. C.

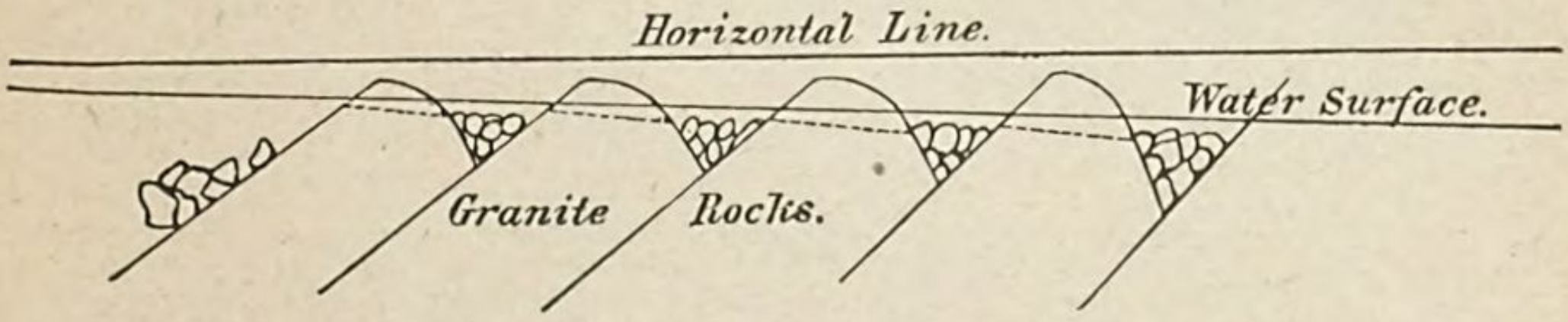
Twice, while going up, the river was badly swollen by rains, but on returning the water had subsided at the places which were then deeply covered. In general, during the examination, the water was at what is there called "a good winter stage,"

being from 1 to 3 feet higher than the lowest water of summer. At this height many of the bad places were covered but their nature and extent were revealed by the sounding pole. As we passed along, I carefully noted every obstruction, its magnitude and extent as given by the pilots. Investigation usually confirmed their statements.

In general, the river above Augusta flows through a valley averaging perhaps one-third to one-half a mile in width. The immediate banks are from 15 to 20 feet high, thickly covered with various trees in a belt perhaps 60 feet wide. In some few places, where the narrow valley at the side of the river is under good cultivation, there are comparatively few trees on the adjacent banks. On the contrary, where the valleys are unimproved, the trees are large and tall and continuous with the forests beyond. As a rule, a definite strip of trees and brush is left bordering the river on either side. The trees are willow, cottonwood, poplar, gum, sycamore, oak, pine, birch, hackberry, etc. Among the trees is underbrush of various kinds, which being interwoven with vines and brambles forms an almost impenetrable thicket. On the shores of the islands, and on the lower banks, dense canebrakes are found. As a rule the immediate banks of the river are higher than the general level of the narrow valleys beyond. At short intervals ditches have been cut, which are now quite large, and serve to lead at once into the river water which otherwise might temporarily lodge there in times of rain.

These river bottoms from about 20 miles above Augusta to the head of Trotter's Shoals, and from Craft's Island, at 88 miles above The Locks, to Andersonville, S. C., are very fertile. At other places the bottoms are poor. Crops are made quite uncertain on the bottoms by the overflows to which they are liable nearly every year.

The map and profile which I submit herewith show the nature and extent of shoals and pools, as well as can be done on the small scale chosen. Unless shown or specified to the contrary, all *obstructions* are rock. The bottom of the river changes from rock to gravel and sand. The latter forms the greater portion of the bed. What little gravel has been shown on the map is made up of stones weighing from 2 to 100 pounds. In many cases, while it is too low to strike boats, it affords a very bad footing for poles. The shoals represented consist usually of ledges of rock which crop out most often at right angles to the channel. The dip of these ledges is usually quite sharp with or against the current, making the obstructions comparatively short in line of the river, with an abundance of water both above and below. The usual case is represented in this sketch.



The rocks of the river-bed are various granites. In the upper river, from Andersonville to Middleton Shoals, mica predominates in its composition, making a rock which is much disintegrated in long exposed surfaces. This rock in its natural state, in quarries, is very hard and makes very strong masonry. From Middleton Shoals to Scott's Shoals, 15 miles above The Locks, the rocks are almost quartzites. Below Scott's Shoals is found the ordinary hard granite, layers being much broken up by seams.

The waters of the river carry large quantities of silt, brought in from the numerous tributary streams and ditches. The Tugaloo River and Little Beaver Dam Creek at Andersonville are the only exceptions. Both bring in clear waters (in ordinary cases) from a mountainous country. This silt fills up the river rapidly in its wide reaches, particularly in that section below the Little River of Georgia, or within 18 miles of The Locks. This is particularly noticeable in the Four-Mile Reach where the sand bar has almost completely choked up the low-water channel, and among the Ninety-Nine Islands above The Locks where the lighter silt deposits in the still water above the dam. Persons acquainted with the condition of affairs at The Locks say that the pond has silted up 5 feet in twelve years, or 5 inches a year since the dam was completed. While on the examination I collected the data and have shown on the profile the heights of two recent freshets on the river, those of August, 1887, and September, 1888. The freshet of 1887 was caused by heavy rain-falls in western South Carolina and in Habersham, Franklin and Hart Counties, in upper Georgia. Comparatively little water came from the Broad and Little rivers of Georgia. At Andersonville (106 miles above the The Locks) the water rose to 15 feet above low water; at Harper's Ferry (76 miles) to 19 feet above low water; at head of Trotter's Shoals (64 miles) to 11 feet above low water; at Petersburg (51 miles) to 32 feet above low

water; at The Locks to 13 feet above low water, and at Augusta (8 miles) to 30 feet above low water. The low water at the head of Trotter's Shoals and the high water at Petersburg is not due to any particular accessions from Broad River, but follows naturally from the slope of the river bed and the formation of the valley. The current of Broad River was lost for the time in the back-water from the Savannah.

The freshet of September, 1888, so disastrous to the city of Augusta, was caused by heavy rains all through eastern Georgia and in most of the bordering Carolina counties, except perhaps Anderson and Pickens.

At Andersonville the water rose to 8 feet above low water; at Harper's Ferry the water rose to 13 feet above low water; at head of Trotter's Shoals the water rose to 6 feet above low water; at Petersburg the water rose to 30 feet above low water; at Port Royal and Western Carolina Railway Branch (8 miles) the water rose to 30 feet above low water; at The Locks the water rose to 19 feet above low water; at Augusta the water rose to 34 feet above low water.

At the freshet of 1887 the Seneca and Tugaloo rivers were high and Broad River low. In that of 1888 the Tugaloo and Broad rivers (principally the latter) were high and the Seneca low. At the beginning of the latter freshet at Petersburg the Savannah River was backed up by the volume of water from the Broad. Between Petersburg and Augusta large volumes of water were poured into the Savannah from the numerous branches on both sides.

By reference to the map and profile it will be seen that the channel of the river is very badly obstructed by rocks and sand, and that the slopes are in many places very steep. To make it navigable for ordinary river steam-boats would be a large undertaking, if it were shown to be possible. As any improvement will depend upon the importance of the river, it was necessary first to collect such information as would show the present and prospective commerce.

Steam-boats running between Augusta and the foot of Trotter's Shoals would draw not only all freights now carried by pole-boats, but a goodly portion of those carried by the railways. The competition offered would draw all freights to and from Augusta and all points in the counties of Abbeville and Edgefield in South Carolina lying between the Port Royal and Western Carolina Railway and the river. Upon the Georgia side of the river, steam-boats could only expect to compete with the railroads on equal terms, the railroads being in most sections at considerable distances from the river. The bulk of the down freights would consist of cotton and cotton seed with lesser quantities of grain, potatoes, wood, and lumber. The up freights would consist of nearly an equal tonnage of fertilizers and miscellaneous merchandise. I have not been fortunate enough to obtain statistics of crops in Georgia since those of the national census of 1880. The counties of South Carolina have increased their productions about 30 per cent. in nine years. Allowing the same ratio of increase for Georgia we have the cotton crop tributary to the river between Trotter's Shoals and Augusta about as follows:*

State and county.	Proportion of country tributary to the river.	Cotton tributary to river.	Present rate by pole-boats. Per bale.	Freight by pole-boats.	Present rate by railroad. Per bale.	Freight by railroad.
		Bales.				
Abbeville, S. C	One-fifteenth	2,442	$1.40	$3,419	$1.25	$3,052
Edgefield, S. C	One-twentieth	2,346	.80	1,852	1.00	2,316
Elbert, Ga	One-fourth	3,000	1.50	4,500	1.25	3,750
Wilkes, Ga	Four-tenths	6,000	1.50	9,000	1.25	7,500
Lincoln, Ga	All	5,000	1.25	6,250	1.25	6,250
Columbia, Ga	Four-tenths	4,400	.75	3,300	.80	3,520
Total		23,158		28,321		26,388

* STATEMENT OF COTTON CROP OF 1888.

The cotton crop of the various counties of South Carolina along upper Savannah River as taken from the report of the Commissioner of Agriculture of that State for 1888 is as follows:

Abbeville, 36,634 bales; Anderson, 30,784 bales; Oconee, 8,078 bales; Edgefield, 46,318 bales.

The cotton crop for the same year for various counties of Georgia is approximated by increasing the amounts given by the national census of 1880 for those counties in about the same ratio of increase which took place in the bodering counties of South Carolina.

The crops would then be as follows: Hart, 7,000 bales; Elbert, 12,000 bales; Lincoln, 5,000 bales; Wilkes, 15,000 bales; Columbia, 11,000 bales.

This assumes that the acreage of cotton per square mile in the parts of the counties included is the same as for the remainder of each county. But let us assume, what is doubtless the case, that the acreage next to the river is from 25 to 50 per cent. greater. And again, the freight rates on steam-boats could not reasonably be more than 75 to 80 per cent. of the present freights by rail. The business would then be represented about as follows:

State and county.	Proportional area tributary to the river.	Increased by greater acreage per square mile.	Proportion of whole crop of country.	Cotton tributary to river.	Steam-boat freight rates, per bale.	Cost of steam transportation.
			Percent.	*Bales.*		
Abbeville, S. C	One-fifteenth	One-half	10	3,663	$1.00	$3,663
Edgefield, S. C	One-twentieth	One-half	7½	3,474	.80	2,779
Elbert, Ga	One-fourth	One third	33 33/100	4,000	1.00	4,000
Wilkes, Ga	Four-tenths	One-fourth	50	7,500	1.00	7,500
Lincoln, Ga	All	None	All.	5,000	1.00	5,000
Columbia, Ga	Four-tenths	One-third	53	5,830	.65	3,790
Total				29,467		26,732

The present freight receipts from miscellaneous down freights are about one fifth those from cotton. The present rate would doubtless exist under steam navigation, making a total revenue from down freights of $32,078.

Assuming as a maximum that the up freights would be equal to those down we have as the total revenue for steam-boats $64,156.

But the benefits of steam navigation can not be measured by the total freight receipts of the boats. It is measured rather by the difference in cost of transportation of goods by steam-boats and the most economical existing method. Assuming, as an extreme case, that all freights must be carried by existing railways and that an average haul of 12 miles must be made on all freights of this section; assuming the present high railway freight rates to continue, their charges on this produce going to market would be $40,010. Railway charges on return freights, $40,010. Haul of an equivalent of 35,360 bales (29,467 by 1⅕) 12 miles, and an equal return freight, 8,000 trips, at $4.50=$36,000. Total expense of delivering produce in market and supplies at plantation per annum, $116,020. Less cost of freighting by steam-boat (allowing no haul by wagon) as above, $64,156. Leaves benefit to agricultural and commercial interests of the country of steam navigation $51,864. Let us now consider the pole-boat commerce between the same points. The cost of carrying freights by pole-boats being greater than by steam-boats, the former are less able than the latter to compete with the existing railroads and will draw the freighting business from a narrower field. We can assume that at least 75 per cent. of the 29,467 bales, or 22,100 bales, or in all down freights an equivalent of 26,520 (22,100 by 1⅕) bales of cotton would be carried by pole-boats. This at the present average price of $1.20 per bale would be $31,824. The extra cost of propelling a boat by poles against the current limits the weight and consequently the receipts on the up trip. At present the receipts from up freights are about 60 per cent. for the year of those down. This makes the total cost of pole-boat freighting $50,918 per year.

The expense of hauling these freights to and from the railways, an average of 13 miles, would be about	$25,000
Railroad freights down, at about an average of $1.15 per bale	30,498
Railroad freights up, equal 60 per cent. of the above	18,298
Total	73,796
Less cost by pole-boats	50,918
Leaves	22,878

per year saved to planters by pole-boat navigation.

In 1876 and 1877 (see Mr. Carson's report in Report of Chief of Engineers, U. S. Army, 1879, part 1, page 760) the down freights were about 12,500 bales of cotton. Assuming an annual increase since 1876 for this region the same as that for South Carolina since 1879 the same country would now produce 16,875 bales, or in all down freights an equivalent of 20,250 bales. Since 1877 the Port Royal and Western Carolina Railroad has been built in Carolina, almost cutting off the greater portion of that

State from the river, reducing the territory tributary to the river by at least one-third. During the years 1885, 1886, and 1887, after the completion of the Port Royal and Western Carolina Railroad, the receipts by pole boats at Augusta from the upper river were about 4,100 bales per annum, or an equivalent in all down freights of 4,920 bales. This decrease of business as compared with the business of 1876 and 1877 is due to (*a*) the building of new railroads, (*b*) the bad condition of the river for boating, and (*c*) to the consequent general depression of the boating business.

The best informed people, who are in a position to know the resources of the country, have made estimates for me upon the commerce of the river, the conditions being those now existing as to railroads, with a pole-boat channel 2 feet deep at the lowest water of summer, between The Locks and Trotter's Shoals and up the Little River of Georgia to Lockhart's Mills, 5 miles:

Down freights, cotton, 15,265 bales	$19,047
Down freights, miscellaneous	4,640
Up freights, miscellaneous	14,313
Total	38,000

This estimate includes only the country immediately tributary to the river as within 5 to 8 miles on the "Georgia" side and half-way to the railroad on the "Carolina" side. Making the previous allowances for increase in agricultural products of the country of about 35 per cent. in eleven years and a decrease of 33⅓ per cent. for the area cut off by the railroads, this estimate is only about 35 per cent. above the actual freighting of 1876 and 1877. This estimate is entirely consistent, as a good channel, at the lowest summer stages, would increase the length of the boating season 80 to 100 per cent. The greater bulk of the up freights would be in the summer months, when, in the present condition of the river, boats can not run for lack of water. These estimates which have been furnished me cover only about two-thirds of the country I have mentioned as being tributary to the river under steam-boat navigation, and are slightly lower than my estimates of the freighting as based upon census reports. A freighting business of $38,000 per annum may then be taken as a safe figure upon which to base estimates of improvement.

As we have seen before, the benefit to be derived by the public from pole-boat navigation on this river is (as $22,878 is to $25,000 or) 91 per cent. of the cost of hauling these goods to and from the railroads. Hauling an equivalent of 18,950 bales of cotton on an average of 14 miles and returning with lighter loads, at a small estimate of 3,790 loads at $4 per load is $15,160, 91 per cent. of which would give us $13,796. Under present conditions the cost of transporting an equivalent of 4,920 bales of cotton 14 or 15 miles could not exceed $4,920, 91 per cent. of which gives us $4,477 as the annual commercial value of the river in its present condition. Subtracting this from $13,796, the estimated commercial value of the river as improved for pole-boats, gives us $9,319 as the annual saving to the planters by a good pole-boat channel at all stages of water between The Locks and Petersburg, Ga.

On and above Trotter's Shoals, steam navigation is clearly out of the question. The value of pole-boat navigation on this part of the river may be shown by the following table. In this, as before, the produce of the country has been taken as nearly as may be from the reports of 1888:

State and county.	Gathered by pole-boats.	Pole-boat rates per bale.	Freight rates per bale.	Length of haul to railroad.	Cost of haul to railroad per bale.	Total expense by wagon and rail per bale.	Freight in favor of boats per bale.	Freight against boats per bale.	Total freight in favor of boats.	Total freight against boats.
	Bales.			*Miles.*						
Anderson, S. C	3,848	$2.25	$1.25	14	$0.90	$2.15	.....	$0.10	.....	$385.00
Oconee, S. C	538	2.25	1.25	12	.85	2.10	.....	.15	.....	80.70
Hart, Ga	1,167	2.25	1.25	8	.65	1.90	.....	.35	.....	408.45
Elbert, Ga	2,000	2.00	1.25	12	.85	2.05	$0.05	.....	$100.00	.....
Total	7,553	.....	.....	.....	.....	.....	.....	.....	100.00	874.15

Whether the crop is more or less than this estimate, or whether other freights are carried, does not affect the case. The above table shows that in the average case under the present favorable distribution of railroads the cost by river exceeds the total expense by wagon and rail. The condition of affairs could be reversed in only two ways, either by a marked advance in rates by rail or a marked decrease of freight rates by boats. The former is made impossible by law and the latter very improbable by the difficulty with which boats are pushed up the steep slopes from Trotter's Shoals to the head. Any ordinary improvement would not make the up trip easier. The simple fact that boats have not for ten or fifteen years made use of this river at winter stages when a full load could be carried is ample proof that commerce can not be carried on by pole-boats at the prices they are able to command. Such is the prospective commerce of the river. Whether it should be carried by steam or pole-boats depends upon the ratio of benefits to costs in each case.

For steam navigation a channel 3 feet deep and 100 feet wide would be required. A narrower channel would be sufficient under low velocities, but in most cases where a channel requires to be cut the velocities would become so great that an ordinary boat could not be safely run in less width of open water. The profile submitted herewith shows deep water on the principal shoals. It however shows the depth in a pole-boat channel, which is often not more than 12 feet wide, the remainder of the ledge being exposed from 1 to 4 feet high on either side. The channel is often very tortuous, so that a new channel would be required, or an entirely new cut made in a different place. As soon as the points of the shoals are cut off the mean velocity of current will be increased, which will lower the surface and increase the extent to which a still deeper cut must be made.

In long shoals, many pools now giving 6 to 8 feet at low water would be so depressed by the cut at their outlet as to require lowering 1 or 2 feet. It is safe to say that any thorough attempt at cutting a channel 3 feet deep by 100 wide between the locks and Petersburg would require cuts about as follows:

One-quarter mile, 6 feet by 100 feet; one-half mile, 5 feet by 100 feet; one mile, 3 feet by 100 feet; two mile, 2 feet by 100 feet; three mile, 3 feet by 100 feet, in rock, total 215,111 cubic yards, at $3	$645,333
Three miles, 3 feet by 100 feet, in sand and gravel, 176,000 cubic yards, at 30 cents	52,800
Total cost of excavation	698,133
Contingencies, 10 per cent	69,813
Total expense of the improvement	767,946

The benefit to the public of this improvement of $51,864 would pay only about 6¾ per cent. interest on this outlay. But it is very doubtful if such an improvement is possible. Such a channel through the shoals must carry all the water of a low river, the excavated rocks being so placed as to accomplish this.

For pole-boats a channel 25 feet wide is ample, with 24 inches of water at the lowest stages. Such a channel might be quite tortuous; in shoal water a turn on a curve of 150 feet radius is easily made. For a good pole-boat channel the improvement would be in the line of obstructions rather than excavation. Cuts should be made through a number of short shoals of rock, but the rock taken out must be used in making dams across the river opposite the deeper part of the cut to throw as much water as possible into the channel. Such dams made low and wide will withstand the force of current in times of high water. In many places dams only are required to raise water over shoals. Channels can be cut through the sand-bars, as in the Four-Mile Reach, by a judicious placing of wing-dams which gather and confine the waters at low stages to a definite channel. The dams previously placed in this reach have not accomplished the desired result. They are of too limited an extent and are badly placed. They can all be used, however, in any intelligent improvement which might be made.

The rapid currents caused by cuts and obstructions at ledges do not affect pole-boats. In shoal water where good footing for poles may be found, a fall of 2 feet in 100 presents no serious difficulty. In going up the boats seek the shallowest part in which they will float. At high or ordinary stages of water this is not in the channel. At extreme low water the up and down channels are often the same. In many cases the deepest water is near one shore. Here the overhanging trees and fallen branches present in many places serious difficulties. Boats often "ground" in endeavoring to avoid these obstructions, which must be removed before they can pass.

The route chosen going up is along the stillest water, which is usually close to the shore, most remote from the low-water channel. A shallow channel is often found quite near this shore, and boats going up in order to "make time" must pass within a yard of shore. At many points this is rendered impossible by the brush, trees, and

snags along the shore. In any intelligent improvement it will be found economical to remove a portion of these obstructions. This, however, must be done judiciously, for in very deep reaches where the longest poles carried will not touch bottom the boats are moved up by "hooking and jamming" against the brush, limbs, and snags along the bank.

In many cases, to make the service more efficient, it is advisable to make or improve an up-channel. From the notes taken no detailed estimate could be made of its cost. In general it would be on shoals and not in vicinity of the down-channel. A few wing-dams would be required. The cost of improving an up-channel would possibly be between one-fourth and one-third of that of the down-channel, or about $5,000. To improve the river between Augusta and Trotter's Shoals no bids for contract work could be expected within a reasonable figure. It could be done most economically by the Government. In my estimates the cost of the boat and steam drills, as well as of all lines, tools, etc., will be included.

I shall exceed my instructions and also recommend the improvement of the Little River of Georgia, as far up as Lockhart's Mills, should it be found advisable after further examination. In this river, which is only about 175 feet wide, three shoals occur. By constructing dams on these shoals and making a cut not more than 10 feet wide the water can be raised so as to carry freights at ordinary low water of summer. The freights to and from Lockhart's Mills under the present unfavorable circumstances are about an equivalent of 3,000 bales of cotton down and 600 tons of miscellaneous goods up. At present two boats run to and from this landing making two trips each per week for four months in the year. This constitutes the bulk of the present freighting upon the upper river.

Detailed statement of the cost of improving a pole-boat channel from Augusta to Trotter's Shoals.

EXCAVATION.

Location of work.	Miles from locks.	Depth of water on shoals.	Length.	Width.	Depth.	Cubic yards.	Cost at $1 per cu. yd.
		Inches.	*Feet.*	*Feet.*	*Feet.*		
Stevens Creek Falls	1¼	12	110	25	1	102	$408
Ledge in "Reach"	3½	12	150	25	1	123	492
Pine Log Shoal	5¼	12	150	25	1	123	492
Little Harvey's Falls (remove ten bowlders)	9½	.....	.....	.....	.....	.....	100
Big Ledge, Scott's Shoals	15	12	270	25	1½	375	1,500
Upper Rounds, Scott's Shoals	.....	.....	30	20	3	67	268
Foot Little River, Scott's Shoals (remove twelve bowlders)	15⅞	.....	.....	.....	.....	.....	120
Sliding Gap Ledge	17⅜	10	100	25	12	90	360
Boiler Ledge	17⅝	11	100	25	11	82	328
Moody Ledge	17⅞	10	120	25	12	106	424
Upper Ledge, Pannel	20⅓	12	100	25	3	267	1,068
In Long Shoals	22¾	.....	20	20	3	44	176
In Long Shoals (remove ten bowlders)	22¾	.....	.....	.....	.....	.....	100
In Long Shoals (remove five bowlders)	23¼	.....	.....	.....	.....	.....	50
In Long Shoals	23¾	.....	20	20	2	30	120
Do	24⅓	18	200	25	½	93	372
Do	25½	.....	30	25	5	110	440
Above Seven Pointers	26⅞	10	40	20	2	60	240
Miscellaneous shoals	.....	.....	300	.....	.....	300	1,200
Miscellaneous bowlders	.....	.....	.....	.....	.....	.....	500
Total	.....	.....	.....	.....	.....	1,972	8,658

Detailed estimate of the cost of improving a pole-boat channel, etc.—Continued.

CONSTRUCTION OF DAMS.

Location of work.	Miles from locks.	Depth of water on shoals,	Length.	Width.	Depth.	Fascines.	Cost fascines, at $1.50 per cu. yd.	Cubic yards stone.	Cost of stone, at $2 per cu. yd.
		Inches.	*Feet.*	*Feet.*	*Feet.*	*Cu. yds.*			
Head of Rapid Gap	1	12	150	10	2	80	$120	50	$100
The Dams, 1881	2	12	1,500	10	1½	417	625	330	660
The Dams, 18— and 1881	3	12	4,000	10	1½	1,112	1,668	880	1,760
The Dams	4½	12	3,000	10	1½	840	1 260	660	1,320
Dam in Scott's Shoals (to be raised	14⅞							100	200
First ledge, Crow Hill	18¼	12	160	6	2			60	120
Second ledge, Crow Hill	18⅓	12	150	9	3			100	200
Upper Ledge, Pannel (repairing dam)	20½		100	10	1			40	80
Miscellaneous shoals			700			300	450	500	1,000
Total						2,749	4,123	2,720	5,440

SUMMARY.

Excavation	$8,658
Stone for dams	5,440
Fascines	4,123
Clearing banks of brush and snags (30 miles, at $35)	1,050
Construction of an up-channel	5,000
Improving Little River, Georgia	500
Boats, engines. pumps, lines, tools, etc	5,000
	29,771
Contingencies (engineering, superintendence, etc.), 20 per cent	5,954
Total	35,725

This estimate can be taken as a safe figure. It will furnish at all seasons of the year an unimpeded channel at least 24 inches deep for boats coming down, and one at least 16 inches deep for boats going up, between Augusta and Trotter's Shoals, 55 miles above the locks, and up the Little River of Georgia, to Lockhart's Mills.

The $9,619, which I have shown such a channel to be worth per annum to commerce, will pay 27 per cent. of the cost of such an improvement. In other words, the benefit will pay the cost in four years, the channel will be permanent, and the improvement will be of great value to the counties bordering the river and to the city of Augusta.

PROTECTION OF THE CITY OF AUGUSTA.

With reference to the protection of the city of Augusta, Ga., from destructive inundations, a complete topographical map of the Savannah River valley between The Locks, 7 miles above the city and Sand Bar Ferry, 4 miles below, was compiled. This work was done between the 7th of November and the last of December, 1888. At the same time data were collected regarding kind and extent of public improvements which might be effected by any change; a brief history of freshets was compiled from records in the United States Signal Office, and from the same source was obtained a detailed history of all freshets which rose above 30 feet at Augusta since 1880, and the daily river gauge readings and rain-fall at Augusta from January 1, 1880, to December 31, 1888. During high and low water the river opposite the city was gauged by means of surface and submerged floats and loaded rods, which gave discharge of the river at those stages. From Mr. Albert J. Twiggs, civil engineer, of Augusta, I obtained velocities of the current which he had measured in the river channel, along streets of the city and at various other places in the river valley at the time of the freshet of 1888. From these velocities the flood discharge of the river was computed.

I submit herewith a map of that portion of the city of Augusta between the canal and the river on the north, and between the canal basin and the city limits on the east and the southeast. This map shows the approximate contours of the city, the level of all street intersections, the level of all canals and canal banks, the level of all railway tracks and bridges and the freshet heights at a large number of points in the city. Besides these, I have shown the elevation, direction, and slope of all sewers with their places of discharge.

Upon a map, also accompanying this report, I have shown contours and limits, as far as might be, of the entire valley from The Locks to Sand-Bar Ferry, with heights of the September freshet of 1888 at all points taken outside of the city. I also submit cross-sections of the river and river valley at a large number of places in and about the city. From these maps and profiles it may be seen that points at or near

the immediate banks of the river are from 5 to 15 feet higher than points near the side of the valley. These banks are at an elevation of 30 to 35 feet. (The datum used is 0′ of the river gauge on the pier of wagon-bridge at Fifth street, which is set at 129.93, or about 130 feet above mean low water at Charleston, S. C.) When the water rises to about 28 feet it begins to overflow into the city in the vicinity of Twelfth street. It is not until the water rises beyond 32 feet that it begins to do any serious damage. Thirty or even 32 feet is a height attained nearly every year. At 34.5 feet during the freshet of August, 1887, while no great amount of damage was done, the water came into the city for several blocks on both sides of Twelfth street and extended back, crossing Broad street. Back-water from the swamps beyond also came into the city from the southeast. During the freshet of September, 1888, the water reached its extreme height early in the morning of the 11th, reaching the highest point known, 38.7 feet. At this height the water covered the entire city north and east of the first and second levels of the canal, even crossing the latter to a very limited extent. The water was from 1 to 12 feet deep over all this ground, running along streets at very high velocities toward the south and east.

The freshet slope in the river along the city was about 6 feet in 2½ miles, and across the city from the northwest to the southeast corners was 13½ feet. A break occurred in the third level canal banks on Tenth street, which let large volumes of water into the city at that point, tearing away houses, etc. The banks of this portion of the canal were built as levees, but only to the height of about 40 feet. At The Locks the water poured over the gates and also, lower down, it flowed from the river some 6 or 8 feet deep over the canal banks. At about 2 miles below The Locks, where the heavy fall of the river had taken the flood-level below the tow path of the canal, breaks began to occur. In the next 2 miles were about three-fourths of a mile of breaks, many of them in very high banks. By these breaks some sixteen or eighteen mills and factories, using some 7,500 horse-power, were stopped about three and one-half months until the breaks could be repaired. The streets of the city of Augusta were in many places very badly torn up, causing numerous breaks in water mains and sewers. The entire damage to the city, the larger portion of which was to private property, has been estimated at 5 per cent. of the assessed valuation of personal and real estate, or about $2,000,000.

Below I give a brief statement of the principal freshets and their heights at Augusta, all referred to the present river gauge:

Eighteen hundred and forty, 37.5 feet (called the "Harrison flood;") 1852, 36.8 feet; 1864, 34.0 feet; 1865, 36.4 feet; 1887, 34.5 feet; 1888, 38.7 feet.

Although the freshet of 1888 exceeded the highest provious record by something over a foot, it is quite probable that freshets may occur in the near future which will go higher than that just experienced. In the present repaired condition of the city and public works another freshet would repeat exactly the same scenes and cause as extensive damages. As the city enlarges, as it is now rapidly doing, these freshets, which one can easily see are sure to come, will cause greater damages. Ample and perpetual protection for the city can be had at a less expense than the estimated damages caused by this last freshet.

Experience teaches that marked eccentricities of humidity follow the extensive destruction of forests. While the mean annual rain-fall of any section may be slightly decreased the amount of water falling in any one week is greatly increased. Marked droughts and more marked floods are liable to occur. Destruction of forests in this river valley has also another effect. Rain falling on cleared lands is gathered quickly into ravines and streams, while that falling among trees is held by leaves and brush. A rain-fall of half an inch may hardly cause a rivulet in a forest, while on open and more particularly on cultivated lands torrents would soon form. The present mode of cultivation also tends to lead the water into the gullies and the river in the shortest possible time. Large gullies are allowed to remain unfilled. Instead of plowing and cultivating the land in horizontal lines along the hillsides, furrows are more often led very sharply up or down hill. The former is the easier method and is followed rigidly in many similar European valleys.

In the river bottoms high up, as a rule, the immediate banks are higher than the major portion of the valley beyond. In nature these pockets along the bluffs are drained through the creeks and branches which occur at no great intervals. In the Upper Savannah Valley each plantation has one or more large ditches leading from these low places to the river. Thus everything seems to combine to increase the liability of the Savannah Valley to destructive floods. It is not at all improbable that between the years of 1865 and 1887 as great rainfalls have been experienced in same territory and within the same length of time as have been experienced since, and that the whole difference in flood heights is due to the increased acreage of cleared and tilled lands. Census has shown that the various crops have increased about 3 per cent. a year for the last ten or twelve years. Doubtless the acreage of cleared land has increased in nearly the same ratio.

Reports upon the Savannah Valley and River at Augusta of about the year 1775, show the Savannah to have been a clear, rapid stream, full of excellent fish and subject to

no sudden or marked changes of height. This was previous to the destruction of the forests and the opening of large tracts of land to the plow. Now the stream has become turbid; the fish, I am told, have nearly deserted the lower waters, and sudden and marked changes of water-level are the rule. To remove these causes is out of the question. To even remedy them in any great degree is not practicable under the present careless style of tillage.

Abstract from record of the United States signal office at Augusta, regarding the freshet of September, 1888.

Date.	Rainfall.	River gauge.	Date.	Rainfall.	River gauge.
1888.	*Inches.*	*Feet.*	1888.	*Inches.*	*Feet.*
Sept. 1	.28	14.8	Sept. 8	trace.	28.3
2	.28	18.4	9	.60	23.5
3	.95	17.7	10	3.11	34.7
4	.06	21.0	11	.....	38.1
5	.17	16.0	12	.....	33.9
6	.07	16.5	13	.....	23.2
7	.17	23.9			

From the 1st to the 9th of September 1.98 inches of rain had fallen. The ground had become thoroughly saturated. Beginning at 3 a. m. on the 9th and ending at 6.10 a. m. on the 10th, 3.71 inches fell. Six hours after the rain recommenced on the 9th, the river began to rise at Augusta, and seventeen hours after the rain had ceased falling the river was at its highest, viz, 38.7 feet. The rain causing this freshet fell mostly in regions not very remote from Augusta. The speed with which the river rose after the commencement of the heavy rains shows this. It was observed also, as I have stated before, that the bulk of the water passing Petersburg was from the Broad rather than from the Savannah. For fifty-nine hours at Augusta the water was above 32 feet, or the height at which the river seriously overflows its banks through the city.

With a view to determining the flood discharge of the river as nearly as possible, some fifteen cross-sections of the bed and valley were made at various points by level and soundings, between Butler's Quarry and Sand Bar Ferry. The former limit is at about 1½ miles above the city, where the bluffs rise from the water's edge on the north and the valley is 1,200 feet wide on the south. At the lower limit the bluffs also rise abruptly at the north, but are several miles distant on the opposite side. On the north side between these two points a valley stretches, which is 1,600 feet wide opposite Augusta. A range of 600 feet was chosen opposite the city for gauging the stream. The site was chosen at a high stage of water when the character of the bottom was unknown. The bottom was afterwards found to be quite irregular, but in all probability little change of bottom took place between high and low stages of river. Although submerged floats were used they were not entirely satisfactory, and the discharge was figured from the velocities of loaded rods. Gaugings were taken at about the highest and lowest stages of water, when the river was nearly stationary. At the high water (24.3 feet) the longest rods available, about 17½ feet, were used. At low water (10.4 feet) several lengths of rods were used, all being placed in the river on the same line at short intervals. From the velocities of all of the rods at each place (which did not strike bottom) a mean velocity of that filament was computed.

After sounding this range at low water and finding the cross section quite variable sections were made every 100 feet in line of the river, beginning 100 feet above the upper range and ending 100 feet below the lower range. These nine sections (see sections 6 to 14, inclusive) were plotted, and a tenth section determined from a mean of these. This composite section was taken as the section over which the velocities were computed.

The formula used for reduction of rod velocities to mean velocities is one adapted from that given by Mr. J. B. Francis in the "Lowell Hydraulic Experiments," and is as follows:

$$Vm = Vr\,[1 - .116\,(\sqrt{D} - x)]$$

in which Vr = velocity of rod,

Vm = mean velocity of the vertical section,

$$D = \frac{\text{depth between bottom of rod and bottom of river.}}{\text{Depth of river.}}$$

x = a function of $\frac{l}{d}$

l = length of rod.

d = depth of water.

The original formula is applicable without correction in cases in which the length of the rod is at least nine-tenths of the depth of the water, and "x" is given as a constant 0.1. I find from observation that by making "x" a variable depending upon the value of $\frac{l}{d}$ the value of Vm will be constant for any one position regardless of the length of rod or the depth of water. For the various values of $\frac{l}{d}$ I used the following values of "x":

When $\frac{l}{d}$ equals	use x equal to
0.9	+0.10
0.8	+0.05
0.7	0.00
0.6	−0.05
0.5	−0.10

From velocities given by the rods I constructed velocity curves (see curves with composite section on sheets of sections submitted herewith). At low water the curve of velocities will be seen to follow closely the curve of depths, coming in sharply from the north side on account of snags and trees on that bank of the river. At the high-water section the curve of velocities departs in a marked degree from this law. The current is thrown from the north toward the south bank of the river as it rises, on account of a bend just above.

From Mr. Twiggs's observations, mentioned previously, which seem to be very consistent, and from the cross-sections at the flood heights, I have computed the total discharge at the time of the freshet. This has been done not only in the river channel but over the South Carolina Valley opposite, and through the streets of Augusta.

The following are the velocities observed by Mr. Twiggs, the height of the river being from United States signal office record:

Location.	Date, 1888.	Hour of day.	Height of river.	Velocities per minute.
			Feet.	*Feet.*
River channel, below city bridge	Sept. 10	10.20 a. m	35. 7	442
Do	10	12.35 p. m	36 4	506
Do	11	9.30 a. m	38. 0	510
Near city, just outside of steam-boats	*			*360
Near trees on South Carolina bank				480
In Hamburgh, between brick-yard and river				320
In Hamburgh, north side of jail				218
In Hamburgh, near Charlotte, Columbia and Augusta Railroad trestle.				240
In Hamburgh, down Main street				180
In Greene street, between Eleventh and Twelfth				260
In Greene street, below Thirteenth				270
Broad, between Fourteenth and Fifteenth ("running greatest up Hawk's Gully toward Greene street").				370
In river, just below Fifteenth. (This measurement is not strictly accurate, possibly 10 feet variation.)				540
In Ninth, between Broad and Greene				200
In Eighth, between Greene and Telfair				180
In Sixth, between Greene and Telfair				150
In Greene, between Sixth and Monument				200
In Telfair, between Fifth and Sixth				180
In Walker, near hospital (below Sixth), about				180
Sixth, opposite Central Railroad warehouse				250
From Miller's mill, by ice factory, toward Port Royal and Western Carolina Railroad.				310

* The time of the remainder of these velocities are not given, but they were doubtless taken on the 11th, when the height varied from 37 to 38 feet.

All measurements of velocities were taken in center of streets, and represent maximum surface velocities. On sides of all streets near fences there was very little current, particularly on the north sides of streets running east and west, and west sides of streets running north and south. The *mean* velocity in streets would not be more than 60 per cent. of measurements made.

From the tables previously mentioned I have reduced the maximum surface velocities, and computing the velocities for other places from Mr. Twiggs's observations I have obtained the total discharge of the river at its flood height. The flow of the river I have divided into three parts: That which passed through the channel, considering this bounded on the south by a vertical plane at the south side of Bay street, and on the north by a vertical plane from the top of the immediate banks of the river, giving a channel 990 feet wide above the banks; that which passed over the South Carolina Valley between the river and the bluff; and that passing through the city. This last item is made up as follows: Water which passed cross-section No. 4 between the northeast corner of Broad and Fifteenth streets and the canal bank near the bridge on Fifteenth street; that which passed through Fourteenth, Thirteenth, Twelfth, and Eleventh from Jones to Broad streets; that which passed along Jones from Eleventh and Tenth streets and along Tenth from Reynolds to Jones; and that which passed through Macarton from river to Jones. This brings us down to section No. 5½, the range over which soundings were taken and discharges computed. In order to check these total discharges of the river I have made computations also over section No. 14½, or that part of it between the south side of Bay street and the bridge; under the lower railway bridge; along the railway from this bridge to the main highway, and along this highway to the bluffs. For this section there must be added the water which passed into the city from the river and Reynolds street to Broad, along Ninth, Eighth, Seventh, Sixth, and Fifth streets, and along Reynolds from Fifth to Fourth streets. For the discharge across Fifteenth street I took the full section between the north side of Broad and the canal bank at a velocity depending on the slope, except in the case of Hawk's Gully where I used a velocity some 12 per cent. greater, computed from Mr. Twiggs's observations there. This section was practically free from obstructions. The remainder of the discharge through the city was computed along a line where the streets are well lined with buildings, close to the street. I estimated that enough water passed through blocks to make the average for the full streets equal to the maximum surface velocities given by computations from section, wetted perimeter and slope.

DISCHARGE OF SAVANNAH RIVER, GEORGIA, AT FRESHET OF SEPTEMBER, 1888.

River gauge, 38.7 feet. Estimated at line of section No. 5½.

[Discharge in cubic feet per second.]

River channel, 990 feet wide from south side of Bay street	212,400
Through the city above Ninth street	39,000
South Carolina shore	49,500
Total	300,900

CONDITIONS IN CHANNEL.

Maximum width, 990 feet. Maximum depth, 39 feet. Mean depth, 29.6 feet.
Available cross section, 29,300 square feet.
Fall per mile, 2.3 feet.
Mean velocity taken at 7.2 feet per second. (Mr. Twiggs's surface velocity=8.5 per second below the bridge is probably slightly greater than at this point. 8.5 feet by 86 per cent=7.31.)

CONDITIONS ON SOUTH CAROLINA SHORE.

Maximum width at section, 1,630 feet. Maximum depth, 12 feet (except a narrow place where it is 18 feet). Mean depth, 9.2 feet.
Cross-section, 15,000 square feet.
Fall per mile, 1.33 feet.
Mean velocity, 3.3 feet per second. (Computations from slope and section would give V_m=4.92, but considering the character of the ground and obstructions of trees, etc., this is perhaps too large by more than one-third.)

DISCHARGE OF SAVANNAH RIVER, GEORGIA, AT FRESHET OF SEPTEMBER, 1888.

River gauge 38.7 feet. Estimated at line of section No. 14½.

[Discharge in cubic feet per second.]

Under railroad bridge on Sixth street	195,260
Through city, at and above Sixth street	41,155
Through culvert under "Carolina Railroad"	5,500
Over same road and through miscellaneous breaks	10,000
Over highway	45,915
Total	297,830

CONDITIONS IN CHANNEL.

Width of river under bridge, 983 feet; maximum depth, 38.8 feet; mean depth, 27.8 feet; cross-section under bridge, 27,327 square feet. (Less section of piers = 1,000 square feet by 1⅓ = 1,333 square feet, leaving available section about 26,000 square feet.)

Observed velocity below, 8.5 feet per second; 8.5 by 86 per cent.=7.31 feet, but the water was 3 feet higher than the bottom of the bridge, which gave it at that point a 3-foot head and increased the mean velocity .20 feet per second, giving a mean velocity of 7.51 feet.

CONDITIONS UNDER RAILROAD CULVERT.

Width of culvert, 180 feet; maximum depth, 8 feet; mean depth, 6½ feet; cross-section, excluding piles, 1,100 square feet; observed velocity reduced and increased by a head of 3 or 4 feet gives a mean velocity of 5 feet.

CONDITIONS OVER RAILROAD ON SOUTH CAROLINA SHORE.

Length, about 1,000 to 1,200 feet; mean depth, 1 foot.

Several washouts increased the cross-section to about 2,000 square feet, and something of an overpour must have had a mean velocity of at least 5 feet.

CONDITIONS OVER HIGHWAY, ACROSS VALLEY.

Width from railroad, 1,040 feet; maximum depth, 12 feet; mean depth, 8.83 feet.

Road is reasonably clear and is about 2 feet above ground on either side. Mean velocity of 5 feet per second is none too large.

This determination of discharge practically checks the determination at the gauging range higher up. The greater discharge should be taken as the flood discharge of the river, or say 300,000 cubic feet per second with a gauge-reading of 38.7 feet.

From these data I have constructed and submit herewith a diagram showing graphically the heights of the river, area of cross-sections of the river-bed and the Carolina Valley, mean velocities in feet per second of the current in both places, and the separate and total discharges at the heights at which the river was gauged and at the freshet height. Connecting the points of determined mean velocity by a curve with reference to the changing conditions and projecting the curve beyond for one slightly greater heights, we have practically all mean velocities of the river, with considerable accuracy, between, say, 5 feet of the gauge, and any height which there is the least liability of being reached by any freshet. About the curve of velocities over the South Carolina Valley there is, of course, some uncertainty. One point, however, is fairly well established. Its lower limit is also determined by the point at which the river overflows its banks, which may be taken roughly at about 35 feet. From the one point we may draw a curve representing mean velocities at higher levels and make it certainly large enough by making its ratio of increase equal the ratio of increase in the main channel just below the freshet height of 1888. Curves representing the sections of the river and valley are drawn from computations of sections at a large number of heights, and above, say 4 feet, may be taken as exact. Discharges are then computed from the values given by these two curves, and two discharge

curves representing the discharges at various heights are drawn. Another discharge curve is drawn, representing the sum of the discharges through the channel, over the South Carolina Valley, and through the city. This represents discharges under present condition. A final discharge curve is constructed, representing quantities which will be discharged by the channel and valley to the north of the south side of Bay street. This represents a condition in which the waters are kept out of the city as by levees. In these curves the ordinates represent the heights of the river by the gauge and the abscissas the discharge of the river in cubic feet per second. By comparing the discharges which would be given to the north of a levee on Bay street with that under present conditions, it will be seen that had the water of the last freshet been kept from the city it would have increased its height only about 16 inches.

The discharge of the river at various heights will show the magnitude of a Savannah River freshet. From this diagram, the discharges for various heights are given in the following table:

Height.	Cubic feet per second.	Remarks.
5 feet	2,000	About lowest water of summer.
6 feet	3,200	
8 feet	6,200	
10 feet	10,400	About the ordinary winter flow.
15 feet	22,700	
20 feet	39,000	
25 feet	59,600	
30 feet	89,600	
32 feet	110,000	
34 feet	136,000	Height of freshet of 1864.
34.5 feet	143,000	Height of freshet of 1887.
36 feet	185,000	
36.4 feet	202,000	Height of freshet of 1865.
36.8 feet	220,000	Height of freshet of 1852.
37.5 feet	253,000	Height of freshet of 1840.
38.7 feet	300,000	Height of freshet of 1888.
39 feet	320,000	
40 feet	370,000	

The lowest summer discharge is about the volume required to give 8,000 horse-power at the city, the whole amount being diverted from the river to the canal at the locks. This has been done, as I was informed by the gate-keeper at that place. This condition has been shown in the profile of the Savannah River from Andersonville, S. C., to Sand Bar Ferry, which I submit. About 1½ miles above the city, at Butler's Quarry, the rapids of the upper river cease, and the pools of the lower river begin. By referring to the profile of the river between Sand Bar Ferry and Andersonville, S. C., it will be seen that above this point the fall is almost 46 feet in 4½ miles. Below this, the fall is scarcely 3 inches per mile for 10 miles. The total fall of the Savannah River between Augusta and the sea is about 134 feet, or something like 6 inches per mile. This fall is, however, not uniform. In the first 8 miles below Augusta the fall is about 2 feet; in the next 10 miles the fall is about 2 feet per mile; then follows 27 miles with 29 feet fall. For the next 225 miles, or to the sea, the fall is about 83 feet. For the first 10 miles below the city of Augusta the fall is so slight and the mean velocity, consequently, so low that the great quantities delivered by the heavy slopes above can not pass between the banks of the river except at a very high level or in a deep channel. Referring to the diagram of discharges, it will be seen that were the water confined to a definite channel, however uniform, along the city 990 feet wide, or about 50 per cent. wider than the average channel, at and 5 miles below the city, the freshet of 1888 would have reached a height of about 43 feet at Augusta. At about 32 feet the river banks begin to overflow below the city and, as the water rises still further, considerable relief is offered to the river all along these banks. This is, however, at the expense of the planters below, whose crops are often destroyed over large areas.

The quantities of water delivered by the upper river at the city of Augusta in times of freshets can not be accommodated in the river channel below the level of the streets of Augusta except by taking advantage of the entire fall offered within 20 miles of the city and constructing a channel of a size at least double that now offered, with a uniform fall. To construct such a channel most economically no deepening would be done above about Ninth street at Augusta. This would give us a limiting depth of water in such a channel of about 33 feet. From these known quantities, fall 2 feet per mile, depth 33 feet, discharge 300,000 cubic feet per second, we find the width of channel

required to be approximately 1,010 feet and a mean velocity of 9 feet per second. Such a channel being cut on a uniform grade and 33 feet deep at the upper end would strike the bottom of the present channel 20 miles below, where the banks are not more than 25 feet high. But the mean surface of the present country, as determined from the slopes I have quoted above, shows that on an average the top of our cut 33 feet deep would be 4 feet below the present surface. This would make an average cut of about 36 feet deep. The cubic contents of such a channel 20 miles long would be roughly, 131,000,000 cubic yards. But the cubic contents of the present channel would decrease the required cut. The present channel will average not more than 800 feet wide and 30 feet deep. Its cubic contents are then not more than 95,000,000 cubic yards. Upon such a channel, then, 36,000,000 cubic yards of excavation would be required. This could be done chiefly with a dredge, but all excavated material would require rehandling to be delivered upon the banks. This could not be done under any conditions for less than 25 cents per cubic yard, or at least $9,000,000.

This estimate does not include cost of ground condemned for the increased size of the cut, and that which would be covered by the dredged material, nor does it provide any factor of safety for the city of Augusta. An increase in extent and height of freshet would overflow the banks and flood the city. Even if no other mode of protection were possible the benefits would scarcely warrant the outlay. Of course a greater fall per mile could be obtained and consequently a narrower channel used by joining the point 20 miles below, with the city of Augusta in a direct line. Such a course would shorten the distance by about 30 per cent.; would increase the fall per mile by about 43 per cent.; would decrease the width of channel about 22 per cent.; and would decrease the depth of cut by about 20 per cent. No use of most of the present river bed could be made; the cubic contents of cut would be increased to about 65,000,000 cubic yards, and its cost to about $10,000,000. (Dry excavation, at about 16 cents.)

It has been suggested that cut-offs be made on one side of the river or the other, drawing the surplus water from some point above the city and leading it back into the channel at some 10 or 20 miles below. By referring to the diagram it will be seen that at 32 feet the height at which water begins to damage the city, a discharge of only about 110,000 feet per second can be obtained through the present channel. The freshet discharge at 38.7 feet was, however, 300,000 cubic feet, leaving a surplus of 190,000 cubic feet per second to be accommodated in other channels. A uniform channel to contain this, reaching the river within 10 miles below Augusta, would have the same total fall which now exists in the river.

Upon the Carolina side a channel entering 10 miles below would be at least 12 miles long, which would decrease its fall per mile about 16 per cent. The most economical dimensions of such would be 900 feet wide and 30 feet deep. This would give a mean velocity of 7 feet or a total discharge of 189,000 cubic feet per second. The contents of such a cut, assuming the ground to be low (it is in many places quite elevated), would be about 62,000,000 cubic yards, and the cost, at 16 cents, $9,920,000. Such a cut, entering just above Sand Bar Ferry, would give a fall per mile of only half as great; would be 6 miles long, and to carry this water could not be less than 1,280 feet wide. This, at the same rates, would mean an outlay of $7,200,000. Reaching the river 10 miles below the city on the Georgia shore, this surplus water would require a channel, commencing above Hawk's Gully and connecting with the river at the mouth of a large creek just above "New Savannah Bluff," 8 miles long in a direct line. The total fall available would require a cut 815 feet wide and 30 feet deep, which could be constructed at a cost, considering the low ground passed over, of about $6,000,000. This, however, condemns a strip of ground 1,000 feet wide and at least 2 miles long through the city of Augusta. But whatever cuts may be made to cary the water either wholly or in part, they must enter the river at such a point that the fall below may be sufficient to give a velocity great enough to carry off the entire flow of the river in a single channel. If such a velocity can not be obtained below the point of junction, the waters will rise, decrease the fall in the separate branches, and consequently the velocity, and cause a rise back into the undivided river. At no point within 10 miles of the city could such cuts enter and not cause nearly the same rise which any given discharge gives under existing conditions. It is even more probable that 15 miles is not too far below the city for cuts to enter in order to reach a fall per mile which would give no backwater.

Other cities less favorably situated than Augusta, with reference to freshets, have been effectually protected by levees. Such protection if sought here must be made sufficient for all possible needs. Banks must either be high enough to be above any possible overflow or must be strong enough to withstand any erosion from water flowing over them. To be entirely safe they must be both high and strong. As protection is asked only for the city and its property, this only would be surrounded by such a dam. The extent and value of the Warwick Mill, located on the east side of Rae's Creek, will not warrant the beginning of a dam so high up. It should, however, be begun at the canal-bank just above the Algernon Mill or about 900 feet above the

tail race of the Sibley Mills; should reach the river bank about 1,600 feet above Hawk's Gully, which it should follow to about 800 below East Boundary street. As far as Bay street extends along the river it is in most cases of sufficient width to accommodate a levee. Leaving the river-bank it would inclose a space about 600 feet wide and return to East Boundary street about 600 feet from the river. It would follow this street and its extension to the south as far as the Port Royal and Augusta Railroad track. Here the railroad "dump" and levee would be combined in one. Leaving the railroad track at its curve to the north it would extend in a southwesterly direction until south of the buildings of the Georgia Chemical Works when it would turn to the west and extend to high land in that direction. Such a levee would be about 30,000 feet long. The approximate position over which its dimensions and cost have been computed is shown on the contour map of the city presented herewith.

The height to which a levee should be built depends upon the area of water-shed above the city, and upon the probable rain-fall. The area drained by the river at Augusta is approximately 8,500 square miles. Very heavy rain-falls, as of 4 inches per day, are liable to occur over small areas. Over areas as large as this river basin, however, a fall of 3 inches per day would be phenomenal, or we could safely say that a fall of 2 inches per day for three days could never be exceeded. Of this amount, falling in this time, at least 1 inch would be absorbed, and the remainder would require five days in passing off. But in passing the city of Augusta it would, at its maximum height, discharge water only as fast as it fell. After the ground was thoroughly saturated the discharge per minute past the city might very nearly equal the fall per minute over this entire area. We have then to accommodate a discharge daily, at maximum level, of 2 inches over an area of 8,500 square miles. This is equal to a discharge of 457,000 cubic feet a second. Adding to this the ordinary discharge per day when floods are liable to occur, about 10,000 cubic feet, we have a total maximum discharge of 467,000 cubic feet per second. From our diagram showing the discharge with levees we find that such a discharge would reach an elevation of about 44.3 feet. This assumed rain-fall is very large, as falling over so large an area. It amounts, under the most unfavorable conditions, to a fall of 4 inches per day over an area of 4,250 square miles, or 2 inches per hour for two hours over an area of 50 miles square, assuming that it all passed the city in twenty-four hours. It is unreasonable to assume more unfavorable conditions than the above. But let us consider what relation this bears to the volume voided by the last freshet.

Allowing, as above, the ordinary discharge for the river when freshets are liable to occur, about 10,000 cubic feet per second at about 10 feet on the gauge, we have as the discharge of water due to the last freshet 290,000 cubic feet per second.

The following table shows volumes voided and heights to which they would reach, for rain-falls of various per cents. greater:

A rain fall greater by—	Volume of water discharged per second.	Maximum heights of freshets.
	Cubic feet.	*Feet.*
10 per cent	319,000	40.4
20 per cent	348,000	41.2
30 per cent	377,000	42.0
40 per cent	406,000	42.7
50 per cent	435,000	43.5
60 per cent	464,000	44.2
70 per cent	493,000	45.0
80 per cent	522,000	45.6
90 per cent	551,000	46.2
100 per cent	580,000	46.9

We see that our estimate of maximum possible rain-fall would give a discharge only about 60 per cent. greater than the highest known. Upon this basis, then, a levee built about 20 inches higher would meet the needs of any ordinary case and would give a factor of safety above estimate of about 16 per cent. At the gauge on Fifth street the levee would then be 46 feet high at crest. Allowing the slope of water along the river at a freshet 46 feet high to be one-half times greater than at 38.7 feet the levee heights should then be as follows:—

	Feet.		Feet.
At canal-bank	53.5	East Boundary street	43.6
Hawk's Gully	51.5	Green street	42.6
Tenth street	48.3	South Boundary street	41.0
Sixth street	46.6	Along south side of city	41.0
Third street	44.9		

Such a levee should have an average top width of 15 feet from the canal-bank to about Fourteenth street, being greater at salient points and slightly less where parallel to the channel. Below Fourteenth street to extreme eastern angle a width of 12 feet would be sufficient; along South Boundary street a width of 12 feet, but of different material; along the railroad the required width of 14 feet, and along the remaining portion 10 feet. Such a levee to be built in the most economical manner consistent with unquestionable permanency, would have a cross-section along the river of the from shown on the sketch herewith.

Slopes are limited by the available space, and in some places are steeper than might otherwise be advisable. Slopes of 1 on 1½ on both sides are safe. Both slopes should be very carefully and closely covered with stone; exposed stones extending at least 1½ feet into bank, upon a bed of finely broken stone about 5 inches thick. Suitable stone is found near, with a quarry fracture which would give excellent faces and joints without dressing. This stone facing should extend to about low-water mark of river, or to 5 feet on gauge, where it would butt against and closely join a line of piles, each at least 12 inches in diameter and 15 feet long, driven closely together, with slabs driven between at the back. On the back side of the levee the stone covering should rest against heavier stone footings 3 feet below the natural surface. The body of such a dike would be made of materials taken from the bank in preparing the front slope. Where such materials are of sand, or any loose materials which water will penetrate, a core wall of brick, 8 inches thick, should be built on footings 2 feet below the natural surface and extending to about 1 foot below grade. Such a wall should be carefully laid up in cement. All materials disturbed should be carefully rammed and thoroughly wetted before stone covering is put on. From the first 2,500 feet from the north end, or until the outer toe of the wall comes within 100 feet of the river, the front toe may safely terminate on broad stone footings 10 feet below the natural surface. In crossing present tail-races of the King and Sibley mills, which should be closed, stone should extend to about 5 feet and terminate on piles as before. Upon the river side of this, between the Algernon Mill and Hawk's Gully, a canal cut for combined tail races should lead along levee. The stone covering on back of levee, extending to piles at bottom of canal, would form the side of the canal. From the second angle after leaving the river (or at station, 17,600 feet) to the end, earth only would be used, with slopes of 1 on 2 on both sides, the whole being thoroughly sodded with Bermuda grass. The reason for using the railroad grade at the south is that, as the tracks must be raised above a freshet line, no property need be condemned, and the work can be done more economically to the public and the railroad company. A core wall should be used in this earth-bank where needed, the same as before.

The cost of such a work has been carefully computed from station to station from profiles. The figures given are safe and reasonable, all the circumstances being considered.

Filling, 610,000 cubic yards, average rate at 22 cents	$134,200
Stone, 160,000 cubic yards, average rate at $2	320,000
Piles, 15,500 (including slab-work) at $2	31,100
Bricks, two-thirds of length, at 12½ cents per square foot	46,000
Total for levee, excluding bulkheads	531,300

Should it be desired to make a carriage drive on top of this levee as far as possible, the top should be paved along the unprotected portion, and the width at all points increased to about 16 feet. This could be accomplished at an additional expense of about $35,000.

Incidental to building a levee comes the question of sewerage; of water power; of raising certain highways and railroad bridges; of elevating the railroads above the principal streets, in order to get in and out of the city above the levee levels; of grading streets crossing levees, and of miscellaneous changes which would require to be made.

* * * * * * * * * *

To summarize the cost and damages incident to protecting the city in the manner pointed out:

Levee, complete, including bulkheads	$531,300
Bulkheads	95,000
Collecting basin for sewage	26,000
Intercepting sewers	18,750
Second and third levels of canal to south levee	24,700
Canal from Algernon Mill to Hawk's Gulley	56,044
New highway bridges, across second and third levels	25,500
Grading street approaches	4,500
City wharves and bridge	10,000
Raising railroad bridges	15,000

Raising passenger tracks	$452,000
Miscellaneous damage to freight yards, depots, etc	130,000
Raising trestles, etc., in South Carolina	9,000
Damage to private property in Georgia	50,000
Damage to private property in South Carolina	2,000
Total	1,449,794
Add for engineering, about 3½ per cent	50,206
Total	1,500,000

An outlay then of three-quarters of the estimated damage done by the freshet of 1888, or of 3¾ per cent. on the taxable property of the city, will permanently and effectually protect the city, besides increasing its present resources to a large extent. Such a levee will not limit the expansion of the city until it has reached twice its population and thrice its wealth. One half of the area within the proposed levee is unoccupied or at most very thinly settled. Many localties which are not occupied on account of the liability to overflow will then be placed on a par with the best locations in the city.

Another means of protecting the city is by impounding the waters of freshets at points above the city.

From a scale of heights made from records obtained at the United States Signal Office at Augusta, we find, as I have stated, that the water was above the danger point of 32 feet for fifty-nine hours. From the heights at each hour discharges were obtained by inspection of discharge diagram. The mean discharge during this time was 206,500 cubic feet per second. The capacity of the river is, as we have seen, 110,000 cubic feet below 32 feet of the gauge, leaving an average surplus discharge of 96,500 cubic feet per second for fity-nine hours, or about 20,500,000,000 cubic feet. Had this amount of water been properly impounded no overflow would have been caused at the city of Augusta. To determine anything like the mimimum estimate on such reservoirs would require a special survey. Partial information was obtained at time of examination to determine the cost of such works, but that they are so located as to give maximum results from a minimum outlay is not to be supposed.

A dam located at the head of Long Shoals, at about 27 miles above The Locks, could be made to such a height as would nearly fill the valley with water at that place. The topography of the country would warrant a freshet height of about 65 feet above low water. In attaining a freshet height of 65 feet, it is not intended to build a dam of this height. A dam 50 feet high will have nearly this effect. An overpour nearly equal to the width of the river, or about 900 feet wide, could be used. A dam at this point would control almost entirely the flow at Augusta. In any freshet a large area of gates would remain open to just keep the water at Augusta at a safe height. As the water raised, so as to flow over the dam, the gates would gradually be closed, until, if that point should be reached, the water would pour over the crest of the dam at the rate of 110,000 cubic feet per second. With this length of crest the water would be upwards of 10 feet deep. The width of such a pond, at such an elevation at the dam, would be about one-half mile. But the trees bordering the banks in the valleys and on the hill-sides would leave an available channel of only about 1,100 feet. Calling the mean depth of pond 40 feet in such a channel, we find that about 0.25 foot fall per mile is required to carry this discharge of 110,000 cubic feet per second. Such a pond would then be about 31 miles long. The mean width of this part of the river at an ordinary stage of water is about 670 feet. Its mean depth in the pond above this stage would be about 46 feet in the channel. The mean width upon the valleys would be about 2,000 feet, with a mean depth of 32 feet. Mean cross-sections of valley would then be about 74,820 square feet. The cubic contents of the pond would then be about 12,250,000,000, or about 60 per cent., of the total discharge of the September, 1888, freshet, above 32 feet. Such a dam should be built of dry rubble, from quarries near, thrown in place by dump-cars from an overhead track.

* * * * * * *

At this location the dam would be on rock bottom.

* * * * * * *

A lock should be put in for pole-boats.

* * * * * * *

The expense of such a dam, 50 feet high, would be as follows:

140,000 yards dry rubble, at $1	$140,000
160,000 yards dirt, at 20 cents	32,000
22,000 yards of masonry, at $8	176,000
Gates and machinery	15,000
Total	363,000

Contingencies, engineering, etc., 10 per cent	$36,300
	399,300
Land covered by 7,500 acres, at $10, less value of timber standing, at $5 per acre	37,500
Total	436,800

An equal outlay in much lower dams on Little River, Georgia, above Lockhart's Mill; Little River of Carolina, Broad River of Georgia, Big Genecostee Creek, and Big Beaver Dam Creek would control an equal amount of water. Such dams need not exceed $1,000,000 in total cost to control a freshet of 40 per cent. greater than that of September, 1888. Higher up, the Broad and Tugaloo rivers might be dammed with good success. Above navigation much masonry construction can be dispensed with.

Such dams would not only serve to effectually control the floods at Augusta and controlling them would be of inestimable benefit to agriculture in the lower river valley where the lands are now so often inundated. By carrying these dams farther, so as to double the impounding capacity required for the protection of Augusta, the entire river valley with its agricultural interests could be protected from destructive inundations.

In the examination in and about Augusta valuable assistance was given me by Mr. Albert H. Davidson, city engineer of Augusta.

Very respectfully, your obedient servant,

GEO. W. BROWN,
Assistant Engineer.

Lieut. O. M. CARTER,
Corps of Engineers U. S. A.

APPENDIX 2.

Down-stream commerce passing through canal locks at Augusta.

Date.	Georgia.								Carolina.				
	Cotton.	Cotton-seed.	Wheat.	Wood.	Guano.	Lumber.	Oats.	Barley.	Cotton.	Cotton-seed.	Wheat.	Corn.	Wood.
1884.	*Bales.*	*Sacks.*	*Sacks.*	*Loads.*	*Sacks.*	*Loads.*	*Sacks.*	*Sacks.*	*Bales.*	*Sacks.*	*Sacks.*	*Sacks.*	*Loads.*
September									33	75	19		6
October	146								156	657			10
November	295								166	698			10
December	626			4					247	260			6
1885.													
January	345			11					220	75			9
February	300			11					39	41		4	12
March	47	40		17					43				7
April	2			11						5			12
May	2		10	5									8
June	2			1									2
July				23									1
August				19									3
September	43			8	116				117	201			1
October	296	13		20					119	211			
November	822								310	431			
December	758			21					416	243			29
1886.													
January	304			20					75	36			14
February	426			35					308	61			20
March	69			16					76				13
April	26			17					11				5
May				10									3
June													
July						10							
August													
September	7			5		3			10				
October	343			3					161	158			
November	1,114			5					157				3
December	673			15					211	262			5

Down-stream commerce passing through canal locks at Augusta—Continued.

Date.	Georgia.								Carolina.				
	Cotton.	Cotton-seed.	Wheat.	Wood.	Guano.	Lumber.	Oats.	Barley.	Cotton.	Cotton-seed.	Wheat.	Corn.	Wood.
1887.	*Bales.*	*Sacks.*	*Sacks.*	*Loads.*	*Sacks.*	*Loads.*	*Sacks.*	*Sacks.*	*Bales.*	*Sacks.*	*Sacks.*	*Sacks.*	*Loads.*
January													
February	215	25		5					50	105			5
March	90	55		9					3				4
April	4			4					12				9
May	82			3					4				5
June	84												2
July													
August	38		6	2			26	6	1				2
September	156	33							153	318			5
October	703								314	729			
November	1,204								347	707			
December	804	200							127	264			8
1885	2,617	53	10	147	116				1,264	1,207		4	84
1886	2,962			126		13			1,009	517			63
1887	3,380	313	6	23			26	6	1,011	2,123			40
Total	8,959	366	16	296	116	13	26	6	3,284	3,847	19	4	187
Mean	2,986	122	5	99	39	4	9	2	1,095	1,282		1	62

APPENDIX 3.

Extracts from the census of 1880.

SOUTH CAROLINA.

Counties.	Corn.	Wheat.	Oats.	Rice.	Irish potatoes.	Sweet potatoes.	Cotton.	Improved farms.	Unimproved farms.	Farms.	Stock.	Farm implements.	Products.
	Bushels.	*Bushels.*	*Bushels.*	*Pounds.*	*Bushels.*	*Bushels.*	*Bales.*	*Acres.*	*Acres.*	*Value.*	*Value.*	*Value.*	*Value.*
Aiken	377,922	22,584	54,339	490,012	2,072	81,895	14,334	102,783	349,276	$2,523,711	$385,311	$112,072	$1,129,227
Anderson	492,646	101,950	94,613	33,857	6,982	36,550	21,897	192,820	254,930	3,119,047	442,874	119,909	1,660,102
Edgefield	559,086	67,841	415,243	660	6,349	70,756	35,894	241,660	387,289	3,879,811	686,361	178,412	2,431,956
Oconee	268,899	26,017	39,392	3,945	2,722	11,331	3,818	59,013	222,624	1,298,123	183,410	34,652	421,842
Pickens	314,061	31,663	23,987	30,460	2,157	20,088	5,756	70,963	177,258	1,023,366	149,797	35,583	502,960
Abbeville	471,955	107,608	249,981	8,865	7,749	31,123	26,380	275,735	305,119	3,013,094	482,301	145,481	1,789,299
GEORGIA.													
Banks	147,981	21,935	18,638	.....	77	4,055	2,960	32,738	87,765	535,407	101,536	20,773	273,790
Columbia	93,191	7,151	50,105	.....	2,534	22,739	8,313	58,237	101,601	786,556	160,303	30,604	564,052
Elbert	212,058	48,883	46,883	.....	1,656	13,536	8,826	86,613	119,412	1,347,133	208,609	40,730	676,663
Franklin	229,779	39,434	31,634	.....	1,982	23,208	5,723	66,237	134,759	1,063,669	180,543	47,117	487,626
Habersham	172,806	12,923	15,036	12,140	886	11,192	597	30,022	151,458	498,470	100,309	15,170	174,106
Hart	126,958	24,977	28,453	.....	1,612	13,617	5,094	43,750	82,942	672,492	136,284	31,439	370,692
Lincoln	87,317	15,431	73,380	.....	1,180	12,895	3,861	39,245	100,387	536,920	115,365	27,284	339,389
McDuffie	87,614	17,367	57,864	.....	1,037	37,016	7,439	60,663	64,849	745,105	197,978	39,829	538,652
Madison	145,422	42,150	32,423	.....	438	8,444	4,918	54,275	117,324	633,278	131,580	42,490	393,726
Oglethorpe	200,584	57,713	59,832	.....	7,846	25,071	12,336	97,536	155,496	1,315,257	250,681	62,432	791,807
Rabun	115,456	1,870	2,823	750	5,282	8,312	14	19,451	168,908	225,490	94,988	11,738	86,272
Richmond	102,619	13,553	73,155	3,765	1,223	51,697	8,467	40,071	86,689	1,267,155	179,702	52,304	398,465
Taliaferro	83,239	20,617	38,769	.....	620	17,499	4,758	49,570	58,695	548,942	100,403	27,887	308,908
Wilkes	191,218	32,732	133,277	.....	2,296	24,962	11,109	97,159	155,623	1,278,174	245,305	62,400	824,594

APPENDIX 4.

Duration and amount of rain-fall and river heights at Augusta, Ga., 1881 to 1888. (Abstract of special cases.)

[Zero of gauge equals low water of 1835.]

Date.	Rain.				Wind.	River gauge.	Remarks.
	Commenced.	Ended.	Duration.	Fall.			
1881.			*Hours.* *min.*	*Inches.*		*Feet.*	
Jan. 20	12 m. (19th)	12.40 p. m. (20th)	12 40	2.08	E	25.08	Rain-fall at intervals during 72 hours.
20	2.53 p. m	8.35 p. m	5 42	.....	.....	.....	
20	11.00 p. m	.....	.....	.....	.....	.....	
21	.....	3.00 a. m	4 00	.15	NW	30.06	
21	6.50 a. m	7.10 a. m	20	.....	.....	.....	
22	.....	.....	.....	.....	W	30.30	From March 17.
23	.....	.....	.....	.....	NW	23.90	
Feb. 9	3.50 p. m	7.10 p. m					
9	10.10 p. m	10.30 p. m	4 30	2.03	N	26	
9	10.50 p. m	11 40 p. m					
10	.....	.....	.....	.....	.....	.....	
11	5.30 p. m	5.50 p. m					
11	7.00 p. m	11.40 p. m	5 00	.57	SW	29	
Mar. 17	9.50 p. m. (15th)	10.20 a. m. (17th)	36 30	3.89	W	28.60	9.50 p. m., 15th, rain. 10.20 a. m., 17th, snow.
18	9.45 p. m	.....	.....	.....	E	32.20	
19	.....	7.55 a. m	10 10	1.27	S	28.40	
20	.....	.....	.....	.....	SW	30.80	
21	.....	.....	.....	.....	SW	28.20	
22	Early a. m	Early a. m	.....	.02	W	19.60	
1883.							
Jan. 18	.....	.....	.....	.52	E	18.10	
19	8.00 a. m	1.10 p. m	5 10	1.06	NE	24.40	
20	2.00 a. m	11.30 a. m	9 30	.98	SE	27.90	
21	4.00 a. m	7.20 a. m	3 20	.14	W	29.11	
21	8.40 a. m	10.00 a. m	1 20	.....	.....	.....	
22	.....	.....	.....	.....	NW	30.70	No reading.
23	.....	.....	.....	.....	SW	26	Water-gauge gone.
24	.....	.....	.....	.....	SE	.....	
25	.....	.....	.....	.01	.....	15	
1886.							
Mar. 27	7.30 a. m	8 10 a. m	40	.....	S	.....	Commenced reading tenths after January 1, 1885.
28	.....	.....	.....	.02	NE	8	
29	.....	.....	.....	3.42	SE	10	
30	11.15 a. m	11.20 a. m	05	1.44	SE	27	
31	12.20 a. m	6.40 p. m	6 20	1.12	SW	30.8	

Apr.	1						SW	32.2	
	2						SW	29	
	3						S	21	
	4						S	15	
May	18	7.45 a. m	10.20 a. m	2	35	.05	S		
	18	9.45 p. m	10.50 p. m	1	05		SE		
	19	9.20 a. m	9.50 a. m		30				
	19	11.12 a. m	11.20 a. m		08	.82		12	
	19	2.35 p. m	6.10 p. m	3	35				
	19	7.15 p. m							
	20		6.45 a. m	11	30	3.63	E	28.7	Large quantity of drift-wood; upper portion city several feet under water.
	20	7.30 a. m	10.25 a. m	2	55				
	20	6.30 p. m	7.05 p. m		45				
	21	2.55 p. m	4.45 p. m	1	50		SE	32.5	
	22	7.30 p. m	8.20 p. m		50	.30	SE	26	
1887.									
July	28	2.10 p. m	2.25 p. m		15		E	6	
	28	6.25 p. m				T.			
	29		6.40 a. m	12	15	4.18	E	14	The river on July 31 was almost stationary; at 6.30 a. m., 34.4 feet; at 9 a. m., 34.5 feet; at 2 p. m., 34.5 feet; at 5 p. m., 34.4 feet; at 9.30 p. m., 34.3 feet.
	29	8.35 a. m	9.00 a. m		25				
	29	11.00 a. m							
	30		6.55 a. m	17	55	1.19	E	32.3	
	30	9.10 a. m	9.40 a. m		30				
	30	8.45 p. m	8.55 p. m		10				
	31	5.15 p. m	6.35 p. m	1	20	T.	SE	34.5	
	31	7.45 p. m	10.15 p. m	2	30				
Aug.	1	11.48 a. m	11.55 a. m		07	.63	S	32	
	1	4.00 p. m	4.15 p. m		15				
	2	6.15 a. m	7.30 a. m	1	15	.08	SW	28.1	
	2	1.45 p. m	3.15 p. m	1	30				
	2	5.30 p. m	5.40 p. m		10				
	3	1.30 a. m	7.50 a. m	6	20	.17	NW	31.7	The following is a record of the river on August 3, 1887: 6.30 a. m., 30.1 feet; 8.30 a. m., 30.6 feet; 2 p. m., 31.7 feet; 5 p. m., 32.2 feet; 8.39 p. m., 32.7 feet.
	4					.10	NW	32.1	
	5						N	23.9	
	6	2.30 a. m	3.00 a. m		30	.10	N	19.2	
	6	12.00 p. m	12.25 p. m		25				
	6	1.20 p. m	1.30 p. m		10				
	7	11.00 a. m	2.45 p. m	3	45	1.38	NW	20.8	From 6.30 to 8.30 a. m. the average rise was .25 of a foot per hour.
	7	8.00 p. m	11.00 p. m	3	00				
	8	1.05 p. m	2.15 p. m	1	10	.96	N	24.2	From 8.30 a. m. to 2 p. m. the average rise was .2 of a foot per hour.
	8	3.00 p. m	3.10 p. m		10				
	8	8.45 p. m							From 5 to 8.30 p. m., .1⅞ of a foot per hour.
	9		3.50 a. m	7	05	1.44	NE	30.8	
	10						S	33.10	
	11						S	24	
	12						NW	15.7	

APPENDIX 4.—*Duration and amount of rain-fall and river heights at Augusta, Ga., 1881 to 1888, etc.*—Continued.

Date.	Rain.				Wind.	River gauge.	Remarks.
	Commenced.	Ended.	Duration.	Fall.			
1888.			*Hours. min.*	*Inches.*		*Feet.*	
Mar. 26	3.30 a. m	3.50 a. m	20	.59	SW	9.7	On March 25 rain fell 1.20 inches during three hours. River 10.2 feet.
26	11.12 a. m	2.45 p. m	3 33				
27	12.10 a. m	5.20 p. m	5 10	1.21	E	22.7	
28	7.25 a. m	11.40 a. m	4 15	1.02	S	27.9	
28	2.05 p. m	2.08 p. m	03				
29				.82	NW	30.6	
30				T.	S	32.7	
31					NW	29.8	
Sept. 1	2.00 p. m	2.20 p. m	20	.28	S	14.8	Rain fell during sixty hours from 29th to 31st of August, 9.2 inches, nine hours and two minutes. Rain-fall, .65.
1	7.45 p. m	8.15 p. m	30				
2	6.12 a. m	7.40 a. m	1 28	.28	E	18.4	
2	12.40 a. m	10.30 p. m	9 50				
3	6.40 a. m	9.00 a. m	2 20	.95	Calm	17.7	River fell to 22 feet at 2 p. m. September 9. Gradually began to rise and at 8 a. m. 10th, marked 34.7 feet, and reached its maximum 38.7 feet at 12.30 a. m. on the 11th. The following are the hourly readings: 8.30 a. m. September 10, 35; 9.30, 35.4; 10.30, 35.8; 11.30, 36.1; 12.30, 36.5; 1.30 p. m. September 10, 36.6; 2.30, 36.8; 3.30, 37; 4.30, 37.1; 5.30, 37.3; 6.30, 37.5; 7.30, 37.6 feet. This was the highest freshet on record at the city, exceeding the Harrison flood 1.4 feet. The city was completely submerged, causing damage that is impossible to accurately approximate. The loss of stock is great, and several deaths from drowning occurred.
3	2.05 p. m	2.15 p. m	10				
4	6.20 p. m	9.35 p. m	3 15	.06	NE	21	
5	10.08 a. m	10.25 a. m	17	.17	NE	16	
5	6.27 p. m	10.15 p. m	3 48				
6	11.42 a. m	2.05 p. m	2 23	.07	NE	16.5	
7	3.00 p. m	3.25 p. m	25	.17	NE	23.9	
8	4.45 p. m	5.20 p. m	35	T.	NE	28.3	
9	3.00 a. m	6.25 p. m	15 25	.60	NE	23.5	
9	7.35 p. m						
10		6.10 a. m	10 35	3.11	W	34.7	
11					Calm	38.1	
12					SE	33.9	
13					S	23.2	

SURVEY OF SAVANNAH RIVER ABOVE AUGUSTA AND BETWEEN AUGUSTA AND ANDERSONVILLE, GEORGIA.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., January 31, 1890.

GENERAL: In accordance with the requirements of section 13 of the river and harbor act of August 11, 1888, and instructions from the Chief of Engineers dated April 1, 1889, I have the honor to submit herewith my report upon the "Survey of the Savannah River above Augusta and between Augusta and Andersonville," together with a project for the improvement of the river and an estimate of the cost of the same.

A detailed description of this stream and information concerning the commercial importance, present and prospective, of the contemplated improvement, are given in my report upon the preliminary examination, dated February 16, 1889, to which I respectfully refer. That examination disclosed the fact that it is not at present advisable to attempt the improvement of the river above Petersburg, and that any improvement below that point should be simply for the purpose of giving a channel practicable for pole-boats. A survey as much in detail as desired could only be made with the river at an extremely low stage, and it was not until in October, 1889, that the field-work could be begun. The survey limited to that portion of the river between Petersburg and the canal-locks above Augusta was made under my direction by Mr. George W. Brown, assistant engineer, whose excellent report is appended hereto.

The basin of the Savannah River above Augusta comprises an area of 7,294 square miles. The extreme low-water discharge of the river at The Locks is about 2,500 cubic feet per second; the ordinary low-water discharge of summer is about 5,000 cubic feet per second, and the greatest freshet discharge is about 300,000 cubic feet per second. The low-water fall of the river between Petersburg and The Locks, a distance of 48 miles, is 120 feet, an average of 2.5 feet per mile.

Leaving out the fall in the vicinity of and below Long Shoals, where the river descends 65 feet in 14 miles, the average fall for the remaining 34 miles is a little more than 19 inches per mile.

The obstructions to pole-boat navigation, given in detail in Mr. Brown's report, consist of sand shoals, ledges of rock, or gravel, and overhanging trees, the principal obstructions being those formed by rock ledges.

To prevent the undue lowering of the pools above by the excavation through the ledges of sluice-ways for pole-boats, it is proposed to raise the crests of those ledges, and in places to construct training-dams to increase the flow of water through the sluices. As the fall over the ledges is considerable, the velocity through the enlarged cuts will be too great for the easy up-stream propulsion of pole-boats, and provision has been made for an improved up-stream channel.

For the construction between Petersburg and The Locks of a down-stream channel, 12 to 25 feet in width and navigable during ordinary summer low water (or for from nine to ten months of each year), for pole-boats drawing 2 feet, and of an up-stream channel navigable under the same conditions for boats drawing 1.3 feet of water, I estimate—

1,900 cubic yards of rock excavation, at $4.50 per cubic yard	$8,550
2,750 cubic yards of riprap stone, in place, at $2.50 per cubic yard	6,875
3,750 cubic yards fascines, in place, at $1 per cubic yard	3,750
Removal of overhanging trees, etc., etc	825
Total	20.000
Engineering and superintendence, 15 per cent	3,000
Contingencies, 50 per cent	10,000
Grand total	33,000

Were the entire amount made available at once, the work could be completed for $23,000. If appropriations are small in amount and irregularly made, the estimates will have to be increased as I have indicated.

The value of the present annnual commerce upon this river is about $300,000. The total freight receipts during 1889, for both up-stream and down-stream freight, amounted to between $25,000 and $30,000. The commerce that would naturally use this stream were it in good navigable condition for pole-boats amounts to about $850,000 a year. As stated in my report of February 16, 1889, no entirely satisfactory and permanent improvement of this river can be effected without resorting to slackwater navigation. The present and prospective value of commerce does not warrant an expenditure sufficient in amount to accomplish this, but I am of the opinion that the commercial benefit to be erived from an impro ved pole-boat channel will justify the expenditure of a sum equal to the estimated cost of such an improvement between Petersburg and The Locks. To this extent only is the river now considered worthy of improvement.

The sum of $23,000 can be advantageously and economically expended during the present fiscal year.

The following papers and maps accompany this report:

1. Report of Mr. George W. Brown, assistant engineer.
*2. Index map of Savannah River between Augusta and Petersburg.
*3. General map of the Savannah River between Augusta and Petersburg (five sheets).
*4. Profile of Savannah River from Augusta to Petersburg.
†5. Maps of detailed surveys of Savannah River between Augusta and Petersburg (seven sheets).

Respectfully submitted.

O. M. CARTER,
First Lieut., Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. GEORGE W. BROWN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., January 30, 1890.

SIR: I have the honor to submit the following report of the survey made of the Savannah River between The Locks above Augusta and Petersburg, Ga., begun in accordance with your verbal instructions of October 7, 1889, and carried out in accordance with the following letter:

SAVANNAH, GA., *October* 12, 1889.

SIR: In accordance with verbal instructions previously given, you will proceed to make a survey of the Savannah River from Petersburg to the canal locks above Augusta. The survey should be sufficiently in detail to enable a close estimate of the cost of obtaining a pole-boat channel to be made. In general, you will be guided by the letter of instructions concerning the survey of the lower river, and dated May 10,

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* Omitted; printed in House Ex. Doc. No. 213, Fifty-first Congress, first session.
† Omitted.

1889, care being taken to carefully locate all rock ledges and other obstructions to navigation, and to determine with accuracy the discharge and high and low water slopes of the river.

* * * * * * *

Very respectfully, your obedient servant,

O. M. CARTER,
First Lieut., Corps of Engineers.

Mr. GEORGE W. BROWN,
Assistant Engineer.

Immediately upon the receipt of your verbal instructions a boat and pilot were engaged, a party organized, and upon October 10 the boat was dispatched toward Petersburg, where the survey was to begin.

Upon the survey it was not possible for me to have personal charge of the work during the entire time. At such time as I was absent from that work Mr. Marion Twiggs, civil engineer, was in charge of the party as surveyor. Alex. Searles, one of the pilots who accompanied me on the examination of the same river in December, 1888, was employed as pilot. The party consisted of a surveyor, rodman, pilot, four boatmen, and a cook. Petersburg was reached on the 15th of October. On going up, no work was done. Notes were taken of the obstructions encountered by boats in going up the river. A gauge was established at Scott's Ferry and a regular gauge reader employed. On reaching Petersburg another gauge was established. Both gauges were read during the survey once each day. A gauge read by the keeper of The Locks above Augusta gives us also the stages of river at that point.

At Petersburg, on October 5, I joined the party, remaining with them for all but three days' work. With them I passed over all but 13 miles of the river.

A compass and stadia survey was made and levels were taken. The manner of procedure was as follows: The transit man first went ahead, taking a backsight on rod held at starting point. There were noted from this sight (*a*) the magnetic bearing, (*b*) the distance by stadia, and (*c*) the level upon the stadia rod used as a self-reading level rod. The rodman usually took turning point or stake or stone at water level, or failing to do so, measured the distance of point either below or above surface of water. With the sounding pole as a self-reading level rod, the instrument height above water level near instrument was taken. With transit in same place the rodman would go ahead and select a turning point, when the bearing, distance, and level would be read as before. With rod remaining at the forward turning point the transit-man would then go ahead as in leveling. Besides the turning points, a sufficient number of points would be located by compass and stadia or by bearings alone to enable a pretty accurate map to be drawn.

In general, besides the turning points, the bearing of the shore above and below, the bearing of lines passing tangent to points or bends and the bearings to upper or lower points of islands were taken. Upon the field sketches drawn from such bearings and distances the channel line was drawn and the soundings taken were put down. The soundings were taken with an iron-shod pole 16 feet long by the pilot from the bow of the transit-man's boat. These were taken as the boat passed from one transit point to the next one down the river, care being taken to get at once into and to follow the exact route taken by loaded boats down the stream. The rod-man used a light bateau, and in moving down would pass the transit point close to the opposite shore. By holding up his stadia rod, the width of the river was taken directly at each instrument point without in any way delaying the work, In passing down, the transit-man would note height and character of banks, size and depths of streams tributary to river, and positions of landings, rock shoal, etc. The instrument used was a Brandis transit No. 584, with level bubble under telescope, and fitted with a 4½-inch needle. With this instrument as a level, the rod used could be read to the nearest tenth under ordinary circumstances at half a mile. The sights taken averaged perhaps 1,200 feet. Longer sights could easily have been taken had it not been necessary to determine water level at more frequent intervals. For level work it might appear that sights of 1,000 to 2,000 feet are entirely too long to give even approximate results. Such a supposition can not hold. With the same instrument and with other levels of the same make under transit telescopes I have repeatedly checked circles of long and irregular sights in actual work as closely as would be done with an ordinary Y level in the same time. The work of other engineers in this district, of a precisely similar character, shows that excellent work can be done with these levels even with very long sights. The errors of long sights are at least not worth considering when we have to deal with rivers having an average fall of 1, 2, or 3 feet per mile. The stadia rod used was graduated to feet and tenths. By means of a table constructed from previous observations the stadia intervals read and recorded were easily reduced to distances. A table was also constructed showing the correction to be applied to level readings for the combined curvature and refraction under mean conditions.

In the ordinary river the rod and transit points were taken on the banks as close as might be to the water. Where rocks showed above the water they were preferred for both.

An ordinary pole-boat having tent over same served for quarters during the survey. Each night as the boat stopped a gauge was established and read at intervals, to determine any change in stage of water during night. Such changes were recorded. Permanent bench-marks were established at beginning and end of survey; in duplicate, near river gauges, and at shoals where work was likely to be needed.

At shoals or places where boatmen experience trouble detailed surveys were made. Usually such shoals were of rock, and consequently of limited extent, so that soundings could be located from transit set up near shoal. In such cases angles were taken to sounding-pole, the stadia interval read from same and the depth noted. Where soundings were taken on sand shoals or farther than 300 feet or 400 feet from instrument, the angles or stadia distance were taken to every second to fourth sounding. The located points were identified from signals made with different-colored flags.

The river was gauged at about 5 miles below Petersburg, and a good determination of the discharge was obtained. No suitable place for gauging was found lower down until the locks had been passed. The two Little Rivers of South Carolina and of Georgia were also gauged. No other tributaries of any considerable size flow into the Savannah between the Broad River at Petersburg and Stevens's Creek, just above The Locks dam. Upon completion of the general survey the Savannah River was again gauged at Augusta, when a good determination was made.

The method employed on the Savannah was as follows: A suitable place having been chosen a base line 200 feet was laid off on bank as nearly parallel as possible to the thread of the river. Soundings were carefully taken and repeated on lines at right angles to base line at its upper and lower ends and at its middle point. The soundings were located by means of stadia rod in boat from transit on base line. Gaugings were made by the use of loaded rod floats. The position of crossing the upper range was determined from stadia rod in boat, the float being dropped into the water from the stern of boat when only a short distance above the range. Its position at the lower range, 200 feet below, was determined by intersection with the transit at upper end of base line. The mean depth for each float was taken as a mean of the depths of the water at the points of crossing the upper, middle, and lower ranges, a value of 2 being given to the depth at middle point. For correction from rod to mean velocities I used the following formula:

$$\cdot Vm = Vr\,[1 - .116\,(\sqrt{D} - x)]$$

in which Vr = velocity of rod,

Vm = mean velocity of the vertical section,

D $\frac{\text{distance between bottom of rod and bottom of river,}}{\text{depth of river,}}$

x = a function of $\frac{l}{d}$

in which l = length of rod,

d = depth of water.

For the various values of $\frac{l}{d}$ the following values of x were used:

When $\frac{l}{d}$ =	use x equal to
0.9	+.10
0.8	+.05
0.7	+.00
0.6	—.05
0.5	—.10

When $\frac{l}{d}$ = +.10 or less the formula is that given by Mr. James B. Francis in the "Lowell Hydraulic Experiments." The corrections given above to Mr. Francis's formula were deduced by myself from a series of observations made when ganging the same stream in 1888. Some unimportant modifications of the above system were used in gauging the small tributaries. The water being too shoal to use loaded rods, the velocities were determined from surface floats. From the obervations of 1888, referred to above, I deduced ratios existing between surface and mean velocities. In the reduction the mean constant, 95 per cent., was applied to each surface velocity for Little River, of Georgia, and 94 per cent. to those of the Little River, of South Carolina. While these constants are not strictly exact for all depths and velocities of these

rivers as found, neither result probably contains an error of 2 per cent. The following are the gauging results:

Savannah River below Petersburg, October 16, 1889, 3,945 cubic feet per second; gauge at Augusta, 6.6 feet.

Little River of South Carolina, October 17, 1889, 176 cubic feet per second. Stage as above.

Little River of Georgia, October 23, 1889, 150 cubic feet per second with gauge at Augusta, 6.3 feet.

Savannah River at Augusta, October 31, 1889, 5,010 cubic feet per second. Mean height of gauge, 6.9.

In order to compare these discharges it is necessary to reduce all to the same stage of river The following are the gauge readings at Augusta during the survey:

Date.	Feet.	Date.	Feet.	Date.	Feet.
Oct. 9	6.9	Oct. 17	6.6	Oct. 25	6.5
10	6.8	18	6.6	26	6.8
11	6.8	19	6.3	27	7.8
12	6.8	20	6.3	28	8.7
13	6.7	21	6.3	29	7.8
14	6.7	22	6.3	30	7.3
15	6.7	23	6.3	31	6.9
16	6.7	24	6.4		

As the stage existing from the 19th to the 23d was the lowest for the year, that height (6.3 feet by the Augusta gauge) has been taken as the stage to which all the gaugings have been reduced.

For this reduction the discharge diagram for the Savannah River at Augusta, accompanying my report upon the Examination of the Savannah River above Augusta, and upon the Protection of the City of Augusta, etc., dated February 11, 1889, has been used with a slight correction for low stages found necessary by the gauging of October 31, 1889.

From this diagram the following discharges at Augusta are found for the various heights of the gauge near low water:

Height at gauge.	Discharge per second.	Height at gauge.	Discharge per second.	Height at gauge.	Discharge per second.
Feet.	*Cubic feet.*	*Feet.*	*Cubic feet.*	*Feet.*	*Cubic feet.*
5.0	3,000	5.8	3,800	6.6	4,650
5.1	3,100	5.9	3,900	6.7	4,760
5.2	3,200	6.0	4,000	6.8	4,880
5.3	3,300	6.1	4,100	6.9	5,000
5.4	3,400	6.2	4,210	7.0	5,120
5.5	3,500	6.3	4,320	7.5	5,800
5.6	3,600	6.4	4,430	8.0	6,600
5.7	3,700	6.5	4,540	9.0	8,400

The following are the results of the gaugings corrected to gauge reading of 6.3 feet at Augusta:

	Cubic feet.
Savannah, near Petersburg	3,660
Little River, South Carolina	160
Little River, Georgia	150
Savannah, at Augusta	4,320

On the survey of the Lower Savannah I gauged the river at Hancock's Landing, about 51 miles below Augusta, on the 27th of June, 1889. The flow there was found to be 5,400 cubic feet per second. The stage of water corresponded with a gauge-reading of about 6.9 feet at Augusta. Between this point and Augusta only five or six creeks of any considerable size enter the river. In comparison with the small streams gauged it is improbable that the total flow into the river between Augusta and Hancock's Landing would vary much either way from 400 cubic feet per second. This may be considered a good check upon the discharge determined. Up to the 23d of October no rain had fallen since the 1st, and none in sufficient quantities to reach the streams since September 24, 1889. The river was consequently quite low at

that time. The following rainfalls are the only ones within the period to affect the stages of water during the survey. They are given in inches.

Date.	Augusta.	Atlanta.	Knoxville.	Charlotte.
Oct. 1	.02	.06	.12	.38
14	.....	.....	.06	.....
23	.10	.44	.26	.02
26	.94	1.32	.90	.38
28	.....	.....	.....	.12

(These quantities are for the day ending at 8 a. m.)

From a mean point on this river Augusta bears southeast about 30 miles; Atlanta bears west about 120 miles; Knoxville bears north-northwest about 170 miles, and Charlotte north-northeast about 110 miles. Of the latter places Charlotte is well up into the foot-hills, and Knoxville is across the mountains. The rainfall of these two places gives comparatively little indication of conditions in the Savannah Valley.

There is tributary to the Savannah above Augusta, 7,294 square miles of country, distributed as follows:

	Square miles.
Seneca River, South Carolina	945
Tugaloo River, including Beaver Dam Creek	970
Various streams between Petersburg and Andersonville	1,062
Broad River, Georgia	1,522
Between Vienna and Little River, South Carolina	51
Little River of South Carolina	553
Streams between Broad and Little River, Georgia	366
Little River of Georgia	748
Little River of South Carolina to Stevens' Creek, South Carolina	85
Stevens' Creek, South Carolina	657
Stevens' Creek to Augusta, South Carolina	42
Little River, Georgia, to Augusta, Georgia	293
Total	7,294

Of this area about 4,720 square miles are above the first point gauged. Immediately previous to the rains on the 22d and 23d of October, this country afforded a mean flow of about .77 of a cubic foot per second per square mile. The Little River, of South Carolina, afforded .29 of a cubic foot and that of Georgia about .20 of a cubic foot per second per square mile. The remaining territory between the first point gauged and Augusta gives a mean flow of about .28 of a cubic foot per second per square mile. These results are very satisfactory when we consider that the streams running through much of the territory above the first point, as the north fork of the Broad, the Seneca, and the Tugaloo have their headwaters in mountain springs, while the remaining streams lower down serve to bring in little more than the surface drainage. Of the lower country, that drained by the Little River of Georgia affords the least water in dry times. This river has the greatest slope. In about 70 miles it has a fall of about 500 feet. A large part of its water-shed lies close to the Oconee River.

From the data given the following table has been constructed showing, within small limits of error, the flow of the river at various parts corresponding to a gauge-reading of 6.3 feet at Augusta. To this has been added a table showing (but with a less degree of certainty) the flow of the river at the same places corresponding of 5.8 feet. (This reading at Augusta has been assumed from data to be given farther on in this report to be the reading corresponding to summer low water of the river.)

[Cubic feet per second.]

Locality and stream.	At gauge-reading of—			
	6.3 feet.		5.8 feet.	
	Flow from tributaries.	Flow of Savannah River.	Flow from tributaries.	Flow of Savannah River.
Above Petersburg and Broad River	.....	2,700	.....	2,380
Broad River and Pistol Creek	860	.....	750	.....
Below Petersburg	.....	3,560	.....	3,130
Fishing Creek, Georgia *et al.*, to Little River of South Carolina	132	.....	115	.....
Little River of South Carolina	160	.....	140	.....
Below Little River of South Carolina	.....	3,852	.....	3,385
Above Little River of Georgia	37	.....	32	.....
Little River of Georgia	150	.....	135	.....
Below Little River of Georgia	.....	4,039	.....	3,552
From Little River to Stevens' Creek	60	.....	55	.....
Stevens' Creek, South Carolina	170	.....	150	.....
At The Locks	.....	4,269	.....	3,757
The Locks to Augusta	51	.....	43	.....
At Augusta	.....	4,320	.....	3,800

For low water the area of the headwaters, including the Broad River, yields a flow of .68 of a cubic foot; Little River, of Georgia, .18 of a cubic foot; Little River, of South Carolina, .25 of a cubic foot; and the remaining lower area of the water-shed, .23 of a cubic foot per second per square mile.

The lowest summer stage of water, only reached as the result of long droughts, will give a flow of probably not less than 2,500 cubic feet per second at the locks. This would correspond with a gauge-reading of about 4.4 feet at Augusta. I am reliably informed that the water has been so low at the locks that at the time it was found necessary to divert all the flow of the river into the canal for power purposes. The power used at the time would require about 2,500 cubic feet per second at the fall available. The exact time when the water was so diverted I have not been able to learn, but it seems to have been in September, 1883, when the gauge showed only 3.8 feet at Augusta. This height on gauge in present conditions of river would indicate a flow of less than 2,000 cubic feet per second. Since the freshets of 1887 and 1888 the river has filled up in the vicinity of the Augusta gauge and for some miles up and down stream at least 1.5 feet, possibly as much as 2 feet.

I have not at hand sufficient data obtained since the filling up of the river at these freshets to determine the mean flow of the river. For the year 1889, however, with a rain-fall of 49.70 inches at Augusta, a mean flow at Augusta of about 12,865 cubic feet per second for the year was experienced. This would equal about 48 per cent. of the entire rain-fall, leaving for evaporation and asorption 52 per cent.

I was not able to make any determinations of the flood discharges. Except in a very few places, all traces of freshet heights had disappeared. None could be found in places where the river valley had a definite and unobstructed cross-section. No freshet heights were found or survey that had not been determined on my examination of the same stream in 1888. The flow found at that time at Augusta for the highest freshet known—that of September, 1888, see my report on the examination, dated February 11, 1889—was roughly 300,000 cubic feet per second at maxium height. These figures would also be true for the discharge at the locks, the high water occurring some time after the water due to local rains had passed. This volume of 300,000 cubic feet per second would correspond to a mean of 41 cubic feet per second per square mile for the whole area of the basin, or a rain-fall, supposing that all passed into the stream and ran off as fast as it fell, of 1½ inches per day. It is probable that at this freshet a fall of 4 inches per day over half the valley was experienced, and at a maximum the water did not pass Augusta at more than two-thirds the rate of fall.

Further considerations of special freshets will be taken up later on in this report.

The survey was completed on October 31, 1889. During most of the time the river was falling slowly. A rain near the close of the work caused a rise of 8 inches at the point where the survey was then being made. This rise was only temporary; it occurred on Saturday night and caused but little trouble. A better time for the survey could hardly have been chosen.

The gauges established were read until December 1, when the readings were dis-

continued. From the readings of the gauges, and from local and boating traditions, I have determined the low-water plane as nearly as may be.

From the data obtained by the observations just mentioned I estimate the following to be the gauge-readings at the ordinary lowest summer stages of the river: Petersburg, .3 of a foot; Scott's Ferry, 2 feet; the Locks, —1.5 feet (1.5 feet below crest of dam); Augusta, 5.8 feet.

The lowest water of the season was on October 23, .3 of a foot above the assumed low water at Petersburg; on October 24, .3 of a foot above assumed low water at Scott's Ferry, and on the following day was .9 of a foot above the assumed low water at the Locks. Had the river been free from effects of recent rains, while being .3 of a foot above at Petersburg, it would have been about .15 of a foot above at Scott's Ferry and .5 of a foot above at the Locks.

In determinating the stage at the various parts of the river referred to assumed low water, I first corrected the whole river to the stage existing on the day the gauge was established at Petersburg and the survey begun. The water was then .9 of a foot above my deduced low water for that place, in a pool having a fall of about 1 foot per mile. The flow of the river was assumed from various determinations to be 1,000 cubic feet per second more than the low-water flow. A table was then constructed, showing heights above low water which 1,000 cubic feet per second would give in the same width of river for slopes varying from one-half foot to 10 feet per mile. A correction was then deduced by which these heights could be corrected for various widths of river. From the slopes and widths of the river the heights above low water at various places corresponding to the stage of .9 of a foot at Petersburg were then determined. These stages were then reduced for the fall of water surface at Petersburg as the survey progressed. By this method, crude as it is, my deductions agreed fairly well with the readings of the gauge at Scott's Ferry.

The depths of the river shown on map and profiles are uncorrected for stage of water. In many places, where the bottom of river is of soft sand, the channel washes out as the water falls. Any given place may show no more depth of water at a 3-foot stage than when the river is at its lowest.

Accompanying this report are—

1. Index map, one sheet, scale 1 inch = 12,000 feet.
2. General map, three sheets, scale 1 inch = 1,200 feet.
3. Profile of Savannah River, one sheet, scale, horizontal, 1 inch = 2 miles; vertical, 1 inch = 12 feet.
4. Profile of Little River, Georgia, one sheet, scale, horizontal, 1 inch = 800 feet; vertical, 1 inch = 3 feet.
5. Twenty-three details, eight sheets, scale, 1 inch = 100 feet; 1 inch = 20 feet; 1 inch = 10 feet.
6. Diagram of gaugings, one sheet.

The index map serves as little more than an index to the general maps.

The general maps exhibit about all of the information collected, except as to levels. The soundings are given in feet and tenths, and are unreduced. Each day's work is distinctly marked, and the stage of water to which the soundings refer is also given. See October 16, when the change is given as 0.9 to 0.6 feet, the range depending upon the slope, width, and depth of river. On these maps the down channel for deep draught is a black dotted line, and is the line upon which a majority of the soundings were taken. The broken black line represents as nearly as may be the usual up-channel for boats with light loads. The positions of rocks and ledges in sight are represented by an arbitrary symbol, thus (⁂), and ledges and obstructions under water but near enough surface to stop a loaded boat are shown by the symbol (×). The traverse line is also shown, and the stations numbered consecutively, beginning each day with No. 1. The odd numbers accompanying a triangle, thus (△), represent transit points, while the even numbers accompanying small circles, thus (◡), represent rod points.

Positions of bench-marks are also shown with their elevations above mean low water at Fort Pulaski given in red. Creeks and "branches" are shown on maps, accompanied by a rough estimate of their low-water dimensions. The heights of the immediate banks are given in many places. These are estimated above existing stage of water. Hachure lines, each system representing a difference of elevation of about 20 feet (except at the immediate banks of the river where one line may represent 20 feet or less), show approximate positions of bluffs, etc., as sketched in the field. The names given upon the maps are for the most part those given by the pilots. When more reliable information was available it was taken instead. It should be remarked that the names given by the colored pilots to creeks, "branches," islands, etc., are frequently those of present property-owners. Thus, Martin's Island is owned by one Martin, and Patterson's Branch flows through the land owned by one Patterson.

The twenty-three detailed sketches are made from detailed surveys of bad parts of the river. The soundings are unreduced. Most of the sketches are accompanied by vertical sections along channel, on which the upper line of each represents water-level

at stages at which soundings were taken, and the red line the assumed surface at low water. On these sections are letters every 100 feet corresponding in position with same letters on details.

On the profile of the river, the water surface was put in from level notes and is represented in a full black line. Profile of bottom is made from soundings. A full red line represents low-water line and a dotted black line 10 feet to 30 feet above the approximate elevation of the freshet of September, 1888. The elevations on this profile and all others given in this report refer to mean low water at Fort Pulaski. These levels have been determined by myself continously between Petersburg and Savannah.

The following table exhibits comparisons between the examination of 1888 and the survey of 1889. It should be borne in mind that upon the examination in 1888, the distances given are a mean between my own estimates and the distances given by the pilots, and that the levels were determined mainly by barometer. I have, of course, corrected all of those levels by a constant quantity, in order to give same elevation at The Locks. For manner of determining distances and levels on that examination, see my report dated February 11, 1889.

Distances.			Levels.		
On survey of 1889.	On examination of 1888.	Error of estimate of 1888 in 4 miles.	Survey of 1889.	Examination of 1888.	Error of examination of 1888 in 4 miles.
Miles.	*Miles.*		*Feet.*	*Feet.*	*Feet.*
0	0	—	156	156	—
4	4	0	166	162	—4
8	8½	+½	171	167	—0
12	11¾	—¾	177	171	—2
16	16	+¼	186	176	—4
20	20	0	204	187	—7
24	24¼	+¼	227	213	+3
28	27¾	—½	246	232	—0
32	32	+¼	256	239	—3
36	37	+1	263	247	+1
40	42	+1	267	251	—0
44	47½	+1¼	270	259	+5
48	51	—¼	276	263	—2
Total error in 48 miles = +3.			Total error in 48 miles = —13′.		

In general, the river between Petersburg and the locks flows through a valley one-half to 1½ miles wide. The immediate banks are from about 8 feet high at lower end to about 25 feet high near Petersburg. They are covered with trees of various kinds, among which are willow, cottonwood, poplar, sycamore, various oaks, pine, birch, gums, hackberry, dogwood, hickory, beech, ironwood, locust, etc, Pines which appear on the higher lands along the upper river are found on the bottoms in the neighborhood of Little River, South Carolina, and Long Shoals, and again near The Locks. The immediate banks are covered with a fringe of trees of a greater or less width, depending on whether or not the adjoining valleys are under cultivation. Among the trees is found underbrush of various, kinds which, being interwoven with vines and brambles, forms an almost impenetrable thicket. On the shores of the islands and on the lower banks, dense cane-brakes are found. In general, the immediate banks of the river are higher than the the general level of the narrow valley. Through these banks ditches have been cut which, being now quite large, serve to lead at once into the river the water which otherwise might temporarily lodge there in times of rain. The river valleys being often overflowed are very fertile, but only where the banks are high and the slopes of the river steep (conditions which render them less liable to overflow) as from Little River, Georgia, to the head of Long Shoals, are they usually cultivated. The uplands all along the river are reasonably fertile, producing good crops of various kinds. Cotton is mainly grown.

Upon the Savannah and its tributaries are several mills, but none of them do more than a local trade. Only one or two grind wheat. All grind corn. Most of them also furnish power to cotton-gins. The following streams are among those which support mills located at some distance back from the Savannah: Broad River, Georgia, Pistol Creek, Georgia, Murrey's Creek, Georgia; Little River, South Carolina; Little River, Georgia; Deep Step Creek, South Carolina; Big Kiokee Creek, Georgia; Jones' Creek, Georgia; Stevens Creek, South Carolina. Of these perhaps Lockhart's Mill,

located about 3 miles above the mouth of Little River, Georgia, is the most flourishing. The following mills are maintained on the Savannah: Bussey's, at the head of Long Shoals; Price's, behind Price's Island; one behind Walton's Island, and one at the north end of the dam at The Locks.

Between Vienna, S. C., and Petersburg, Ga., a ferry is maintained across the Savannah, and between Petersburg and Lisbon, Ga., across the Broad. On the site of the once flourishing town of Vienna only one house remains. The buildings of only one plantation now comprise the town of Petersburg. Lisbon has yet a post-office, kept in a small country store, a blacksmith-shop, one gin-house, and four or five small houses.

The following ferries are maintained below Petersburg: Rimson's, 40 miles above the Locks; Barksdale, 37 miles above the Locks; Ferguson's, 29½ miles above the Locks; Kilcrease, 20 miles above The Locks; Fury's, 6½ miles above The Locks.

No villages, nor even the smallest collection of houses, are found near the river at these ferries, nor at other places within the limits of this survey, except at Woodlawn Station, on the Augusta and Knoxville Railroad, at its crossing into South Carolina, at 7½ miles above The Locks. Here only a post-office in a small store, a depot, and two or three rude buildings are found.

The freshets marks of 1887 and 1888 had disappeared. With one exception I was able to find no point not previously settled at the examination in 1888. For notes on freshets see my report of February 11, 1889. The total information pertinent to the present discussion may be summed up in the following table:

Height above low water at Petersburg, The Locks, and Augusta.

	Petersburg.	The Locks.	Augusta.
	Feet.	*Feet.*	*Feet.*
Freshet of 1852	40	.....	34
Freshet of 1887	32	11	30
Freshet of 1888	31	17	34

In the last column the heights are those above known or assumed low water at the time and place. It might be mentioned in the same connection that it is probable that the highest ranges above low water as far as may be known occurred as follows:

At Andersonville, S. C., the freshet of 1887 rose to 15 feet above low water; at Petersburg, the freshet of 1852 to 40 feet; at The Locks, the freshet of 1888 to 17 feet; at Augusta, the freshet of 1840 to probably 36 feet. At Augusta, the highest freshet known—that of 1888—was only 34 feet above low water, ranging between 4½ feet and 38½ feet, while that of 1830 ranged between 1½ feet and 37½ feet, the river having filled up at the city gauge by probably 3 feet. Of all freshets known the latter voided the most water.

The freshet of 1852, so high at Petersburg, was made up largely of a very heavy rain-fall on that section drained by the Broad River, without unusually large additions from the upper Savannah.

The obstructions to the navigation of the river by pole-boats consist of rocks, rock ledges, gravel, and sand. Except in the reaches or where otherwise noted, the shoal places have a rock bottom. The rocks are granites of various compositions, quartzites, and slates mixed with quartz. They are usually in ledges dipping very sharply against the current. In several places the dip is so sharp it is difficult to tell which was the bottom and which the top at its formation. Through rock ledges the length of one shoal is scarcely more than the depth of a harder layer of rock at its formation.

In many places the obstructions are composed of detached rocks of various sizes, usually on rock bottom. At various places large deposits of sand have been made, particularly in the regions of lightest fall, as in the Four Mile Reach above The Locks and above Little River of South Carolina. In the sand many places showed not more than 2 feet of water during the time of the survey. In most of these places, particularly in the upper reaches, the shoals have always lowered with the fall of the water. In the Four Mile Reach, where in 1881, 1882, and 1883 about thirty pairs of short dams were constructed to improve the channel, the sand deposited by high rivers does not wash out as the river falls, for the reason that the river is too wide to sufficiently concentrate the flow. The dams built here are of the general form in use upon the Savannah River below Augusta, and described in various reports of the Chief of Engineers. They were built entirely upon the left side of the river, the evident intention being to make a channel of 20 feet in width about 30 feet from the river bank. As this work now stands the channel leads down between the first three pairs of dams, outside of the fourth and fifth pairs, between the sixth and seventh pairs, and outside of all the remaining dams. The channel, which might have existed

among the dams, was abandoned because the deposits of sand had choked it up. In one or two instances long sand bars now show up at low water on the site where work was done. That those dams are now useless seems to be the result, in most instances, of bad location; or in some instances, of bad construction. The river is now shoaler in the vicinity of these dams than upon the opposite side. Whether this has been so only since the construction of these dams I have no means of determining.

From a general view of the situation it would seem quite possible that at the time these dams were located the deepest part of the river existed along this bank. That this side should be the deeper would naturally result only from a continuous absence of freshets high enough to overflow the left bank. After these dams were built, even had a good channel been the immediate result, the occurrence of a freshet high enough to overflow the banks by 4 or 5 feet would certainly have caused a deposit of sand upon them and in their vicinity. By reference to the map it will be seen that when the river overflows its banks the bluffs upon the right bank, at about 6 miles above The Locks, will force the water over the low valley opposite the 5 and 6-mile points. The water returning into the river will deposit its heavy load of sand along the left bank between the 4½ and 1½-mile points. It is difficult to conceive of any other result from a high river.

* * * * * * *

In many places where excavation has been done the channel is in good condition. In some cases, however, there seems to have been a lack of proper concentration of water into these cuts. Most of the stone dams adjacent to rock shoals are in a fair state of preservation. Where the dams so built are exposed to the strong current of the river in times of freshets they are, in many cases, somewhat broken. There does not seem to have existed a proper appreciation of the strength of these currents, which may attain a velocity for the whole channel of 15 to 20 feet per second at times of freshets.

The pole-boats now in use upon this river are usually about 85 feet long by 7 feet wide. They are flat-bottomed, drawing when light about 6 inches of water, and when loaded about 20 to 22 inches. Both ends are made sharp. These boats are propelled up stream by poles. Six men—four or five polers—when no load is carried will make 12 to 20 miles per day. With 6 tons of freight eight men will propel a boat about 10 miles per day. With such a load, which is about the maximum freight carried up stream, the boat will draw 13 or 14 inches and will require a channel of about 1.3 feet deep, about 8 feet wide at the bottom and 10 to 12 feet on top. Down stream these boats are carried mainly by the current, steerage-way being given them by two sweeps near bow handled by one man each. Two or three men are stationed on a platform in bow and with poles fend boat from rocks, or in making short turns check and hold bow while the stern is swung around. The steering-oar, which serves not only to guide the boat, but to move the stern bodily when necessary, is handled by from one to four men. The boats are loaded to suit the stage of water. With 30 bales of cotton weighing 7½ tons they require at about 1.5 feet of water, while with 50 bales, or 12½ tons, they require about 1.9 feet in which to float without striking bottom. The boats being only 7 feet wide may be run in a very narrow channel if straight. In places where the fall is great, high velocities are attained by loaded boats and a greater width of channel is necessary. Where boats are able to lead into and to pass straight through a clearly marked pass, a width of 10 feet may be sufficient. Except on turns it is not necessary to have a channel more than 18 feet wide. A wider pass through a ledge would give too high a velocity, making it difficult to manage a boat, besides tending too much to lower the pool above.

A better service on this river would be attained by the use of larger boats. After an intelligent improvement of the river the boats could be made slightly larger, and with the same crew would carry up stream one-third heavier freights and bring down one-third more cotton, making the same time as at present. This increase of capacity would benefit not only boatmen, but the planters themselves who often own the boats which carry their freights. Larger boats would not be materially wider and only slightly deeper. They would require a down channel from 12 to 25 feet in width in which flows 2 feet of water.

For a size and style of boat which the commerce of this river will warrant a channel 30 feet wide and 3 feet deep, such as was called for in the abandoned scheme of improvement, is unnecessary. Not only is such a size of channel unnecessary, but for reasons just stated it would be dangerous to navigation, unless nearly straight and would militate against the permanancy of the improvement. For instance, places exist where the fall is perhaps 2½ feet through a single ledge. After such a cut were made a fall of more than 1½ feet in 100 feet could be expected. With a fall 80 feet per mile the velocity in a channel 30 feet wide by 3 feet deep would be about 20 feet per second. The cut would void 1,800 cubic feet per second, or nearly 90 per cent. of the natural flow of the stream at low water. Clearly this could not be allowed without building a dam entirely across the river at the sides of such cuts. If, however, a

cut 18 feet wide by 2 feet deep be made through such a ledge it would give a velocity of only 16 feet per second to only 36 square feet of water, or would carry through only 576 cubic feet per second. This is less than one-third of the flow through the larger channel and only about 25 per cent. of the flow of the river at low water.

I would respectfully recommend an improvement of the river in accordance with the following plan:

A down-channel should have a clear depth of 2 feet, it should be made from 12 to 25 feet in width, depending upon the location and fall and upon the accessibility of the pass. Such a channel should be obtained by cutting through ledges; by the removal of loose rock and coarse gravel; and by the building of dams of stone and fascines, to confine and concentrate the water as may be necessary. Each excavation should be accompanied by proportional obstructions adjacent to same. In no case should the level of the pool be lowered.

An up-channel should be constructed along the stiller water, in most cases near the bank most remote from the channel. In some cases, as through the lighter ledges, the one down-channel would serve for boats going both ways. Usually but little excavation will be found necessary to open up a shallower channel at one side. As in case of down-channel the excavated material should be used in raising crest of ledge through which the cut is made. The up-channel should have a top width of only about 10 feet through cuts and a depth of only 1.3 feet. In the improvement of the river considerable cutting of overhanging trees will be necessary for both up and down channels.

For the necessity of an up-channel, see my report on the examination of Savannah River in 1888, dated February 11, 1889.

For the commercial importance of this river and the advisability of improving same for pole-boat navigation, see same report.

In the following detailed description of the shoals and of the improvement necessary in accordance with the project recommended above, the localities will be described by giving distance from The Locks in miles as shown upon my general map.

First at 39.9 miles, on bank of Murrey's Island, are five overhanging trees in about 100 feet which should be cut, to enable boats to take advantage of deep water close to shore.

The channel is too shoal by about .3 to .4 feet on the Barksdale Ferry Ledge at 37.5 miles. Dams have already been built here on crest of ledge and at sides of sluice. (See Detail No. 20.)

Through this ledge the cut already made should be deepened by .6 foot for 100 feet long by 18 feet wide. This requires the excavation of about 64 cubic yards of rock which should be used with about 16 yards more of stone and 40 yards of fascines in raising and extending old dam. The rock so excavated and placed in dam would cost $7 per cubic yard, while the remaining rock could be obtained on the right bank three-quarters of a mile above and put in place for $3 per cubic yard.

At 35¼ miles the overhanging willows on the left bank should be cut for about 800 feet. Sufficient water could thus be obtained near bank.

At 32.8 miles the left bank should be cleared of overhanging willows for 600 feet.

At 30.3 miles the willows over the channel on left bank should be cut for 500 feet where the channel crowds the shore in passing Hawes' Creek Ledge.

At 29.2 miles the cutting of willows from right bank over channel for 300 feet would give 4 feet of water.

At 28.5 miles a shoal place is met with in Point Lookout. The improvement here should consist of cutting the overhanging willows on Searle's Island from the point f (see Detail No. 19), to a point about 700 feet above. A dam about 180 feet long, located as shown on detail, made of 8-foot fascines and loaded with 36 cubic yards of stone, 1 cubic yard for every 5 feet, would gather sufficient water. About one-half the stone necessary would be obtained in clearing the adjacent channel of its loose rock. The other 18 yards could be obtained within one-half a mile below the work. Half the stone will be put in place at $5 per yard, the remainder will cost $3 per yard. On the work 120 cubic yards of fascines will be necessary.

At 36.2 miles an obstruction is encountered at Indian Jaw near head of Long Shoals. (See Detail No. 18). This is a ledge giving only about 1.3 feet of water. The channel now in use requires a sharp turn both on entering and leaving pass in ledge. By cutting channel farther to left at upper end and farther to right at lower end boats could pass through nearly straight. Owing to heavy fall a channel of not more than 15 feet wide should be cut. (See Detail No. 18 for plan of improvement.) The least water in channel is now only 1.4 feet at low water. The cut should be about 75 feet long, 15 feet wide, and about 1.2 feet deep, on an average. About 80 yards would be taken out. The excavated material should be combined with about 60 yards of fascines and used in closing up gaps in crest of ledge for about 350 feet. The ledge adjacent to cut should be raised up by this material to about the height of low water. The excavating and placing of rock in dams would cost about $7.50 per cubic yard.

A ledge in the Heart of Stuman at 24½ miles gives only about 1.2 feet at low water.

(See Detail No. 17.) A cut should here be made 15 feet wide and about 1 foot deep for 40 feet, requiring the removal of about 40 yards of rock. The rock so removed, supplemented by about 30 yards obtained elsewhere, and combined with 50 yards of fascines, should be used in raising crest of ledge to a height of low water, and possibly in construction of dams on each side of cut. As above, excavated rock would cost in dams about $7.50 per yard, while the balance necessary could be obtained one-quarter of a mile below, at a cost of $2.50 per yard in finished work.

At 24.1 miles are found a succession of shoals in Dordon Creek Ledges. (See Detail No. 16.) The shoals give now about 1.1 feet, 1.5 feet, .9 foot, 1.7 feet and 1.2 feet at low water. The following cuts should be made:

	Cubic yards.
At *d–e* 15 feet by 100 feet by .8 foot	72
g 18 feet by 50 feet by 1.0 foot	53
h 18 feet by 25 feet by 1.3 feet	35
k 18 feet by 25 feet by .6 foot	16
m 18 feet by 30 feet by 1.2 feet	38
Total	214

About 100 yards of stone with 160 yards of fascines should be used on upper ledge in raising crest of same to low water for about 300 feet and in building a training-wall 100 feet long to about same height at the left of cut. (See Detail.) The ledge at "*g*" would require about 30 cubic yards of stone and about 25 yards of fascines in raising crest for about 50 feet on either side. The ledge at "*h*" would require about 30 cubic yards of stone and 25 yards of fascines in raising crest about 25 feet to right and 40 feet to left of channel and in placing short dam along left of channel, as shown. The remaining 54 yards of stone should be used with about 75 yards of fascines in raising crest of ledge at "*m*" and in building a dam on left side of cut about 25 feet long. rock so excavated and placed should not cost more than $7 per cubic yard.

At 23¾ miles a bad ledge occurs, at Elbow Gap. The channel passes obliquely between two ledges. (See Detail No. 15). At low water a much sharper turn is made here than is shown. In order to make a safe channel it is necessary to cut off end of upper ledge. The cut should be 20 feet wide by 75 feet long by 1.2 feet deep, containing about 107 cubic yards. This stone, with about 80 yards of fascines, should be used in closing up crest of ledge near cut and in constructing a dam about 40 feet long on left side of channel, 30 feet below "*k*," as shown on detail. The rock here is softer and more easily removed. The fall here is not so great as in previous cases. The cost of removing this rock and of placing it in dams mentioned should not exceed $6 per yard.

At 22¼ miles is a shoal place in Cold Rain Ledge, at foot of Open Sluice. (See Detail No. 14.) To improve this place would require a cut about 15 feet by 25 feet by 1 foot deep, containing about 23 cubic yards. The excavated rock, with about 37 yards additional, together with about 40 cubic yards of fascines, should be used in filling crest of ledge and in building a dam, parallel to and at the right of the channel as shown, about 35 feet long. The 23 cubic yards of excavated rock would cost in dams $7 per yard. The 37 yards additional stone required could be obtained one-fourth of a mile below and would cost about $3 per yard.

At 21.8 miles overhanging willows along left bank should be cut for about 300 feet.

At 21.5 miles about 20 feet of the point on the left of the channel in Spring Ledge should be cut off. The ledge is here about 25 feet thick. About 20 by 25 by 2½ feet, or 75 cubic yards, of stone should be removed. This rock should be combined with about 40 yards of fascines, and used in closing up larger gaps in ledge and in building dam about 50 feet long at the end of the next ledge below. Said dam should be on the right-hand side of the channel. Six dollars per yard would suffice for both excavation and construction.

At 20¼ (see Detail No. 13) are four shoal places in Pannel's Ledges. At "*c*" (see Subdetail A) a cut should be made 50 by 18 by 1 foot, requiring the removal of about 53 yards of rock. Just below "*d*" a cut should be made of 15 by 18 feet by 1.2 feet—equals 19 cubic yards. At "*f*" (see Subdetail B) a cut should be made, having a total length of 32 by 18 feet wide and 1 foot deep, containing 34 yards. At "*o*" (see Subdetail C) two cuts, having a total length of 48 by 18 feet wide and 1.5 feet deep and containing 77 yards, should be made. The big ledge should be closed up to low water by the use of about 70 yards of stone and 40 yards of fascines. This material would probably complete crest to required height for 150 feet on either side of cut. At "*f*" a dam 150 feet long should be constructed along the left side of the channel, and upon the right one about 175 feet long should be built as shown. For these dams 145 cubic yards of fascines and 70 yards of stone would be required. Twenty cubic yards of fascines and 30 of stone should be used in closing up crest of second ledge opposite "*e*," beyond upper end of dams last mentioned. At "*o*" 90 yards of stone and 100 of fascines are required to build short training-walls on either side of channel and to

close up crest of ledge for about 225 feet to left and to island at the right. The 183 yards of excavated rock will cost in dams about $6.50 per yard. The remaining 77 yards of stone necessary for this place can be obtained just above the ledges on the left bank at a cost not to exceed $2.50 in place.

Garden Shoals at 20 miles (see Detail No. 12) carries about 1.4 feet of water in shoalest part. It should be deepened by a cut 18 feet wide having a total length of about 95 feet and a depth, mean, of .8 foot. About 81 yards should be taken out. These with about 40 yards of fascines should be used in closing up upper ledge adjacent to cut, or in raising collecting dams between ledges or dams paralled to cut, as may seem expedient. The stone so moved and placed would cost about $7 per cubic yard. This channel through Garden Ledges is preferred to that of Charleston Big Road through same ledges farther to the left. The "Road" affords no more water.

At 18 miles (see Detail No. 11) a shoal with bottom of gravel, rock, and loose bowlders occurs with about 1.7 feet at low water. This place might be improved by cutting the overhanging willows along bank from "*b*" to "*o*," a distance of 1,200 feet; by the removal of various loose bowlders in channel and two large rocks near "*n*," a total of about 30 cubic yards, and by construction of three wing-dams at the right of channel near "*f*," "*k*" and "*n*." These dams should have a total length of nearly 600 feet (at "*f*," 200 feet; at "*k*," 150 feet, and at "*n*," about 250 feet), and would require about 350 yards of 8-foot fascines and 130 yards of rock. The excavated rock would cost in these dams about $5 per yard. The 100 yards additional stone required could be obtained 2½ miles above or at the mouth of Little River, 1¼ miles below, at a cost of about $3 in place.

At 17¼ miles, in Little River Shoals, occurs one of the most dangerous places on the river. This place has been much improved of late. The channel (see detail No. 10) is still quite tortuous when we consider the heavy fall at each of the three ledges. About 1.8 feet of water is found on upper ledge, 1.5 feet on middle, and 1.6 feet on lower. The channel should be improved by straightening, as shown on detail, and by deepening to 2 feet. A cut through Moody Ledge of a total length of 80 feet by 15 feet wide and 1 foot deep is necessary, requiring the removal of 72 yards of rock. From the boiler ledges about 40 yards should be taken out in a cut 18 feet wide. "The boiler" itself should be lowered by about 1 foot for about 15 by 25 feet. The lower ledge obstructions occur at about 25 feet above "*h*," at left of channel; at 30 feet and 60 feet below "*h*" in channel, and on right of channel at "*i*." From these cuts, in order to improve a channel 18 feet wide, about 58 yards of rock must be removed. About 50 yards of stone and 20 yards of fascines should be used in closing gaps in upper ledge adjacent to the channel to the height of low water. A dam 50 feet long should be built close along the left side of the channel at "*d*," requiring 60 yards of fascines and 15 yards of stone. In closing up crest of boiler ledge for about 100 feet on each side of cut and in building a dam about 40 feet long on left of channel, as shown above "*f*," about 110 yards of fascines and 60 of stone would be required. About 50 yards of stone and 50 yards of fascines should be used in raising and closing crest of Sliding Gap Ledge. A dam at the right of the channel about 80 feet long, and one at the left about 40 feet long, as shown at the foot of Sliding Gap Sluice, would require about 80 yards of fascines and 35 yards of stone. The material excavated from the boiler would be washed into deep water below and could not be used. The 22 yards so removed would not cost more than $4 per yard. The rock taken from cuts and built into dams would probably cost $7 per yard. The remaining rock necessary for dams, about 40 yards, could be obtained one-half a mile below at the mouth of Little River, and put in place for $2.50 per yard.

Obstructions are next met with at Chicken Sluice, 15½ miles above The Locks (see Detail No. 9). The river here affords only about 1 6 feet at low water. The channel is crowded close to left bank of river. In channel are numerous ledges and loose rock. About 35 cubic yards of excavation are necessary, of bowlders and loose rock at "*f*," "*h*" to "*i*," "*k*," and "*l*." To gather more water into sluice a dam should be built, as shown at "*g*," about 250 feet long. Another dam should be built on lower ledge near "*h*" about 50 feet long. These two dams would be only about 1.5 feet deep and would require 60 yards of stone and 180 of fascines. At "*s*" and "*t*" on same detail, about 25 yards of rock should be removed, which, with 25 yards additional and 40 yards of fascines, should be used in putting crest on adjacent ledge. The rock excavated in and about Chicken Sluice would cost only about $5 per yard in the finished work. The additional rock necessary in these dams could be obtained from mouth of Little River and put in place for $3 per yard. From "*g*" to "*l*" on the same detail, a distance of 400 feet, and for 500 feet adjacent to "*q–v*," and for 200 feet near Sharpton's Landing, a short distance below, the overhanging willows should be cut away. Adjacent to "*u*," under the willows, better water is found than is shown on plat.

At about 14¾ miles, in Scott's Shoals, four shoal places are encountered (see detail No. 8), giving about 1.3, 1.9, 1.6, and 1.8 feet, respectively. The shoal between "*b*" and "*c*," (see Subdetail), should be improved by a cut 18 feet wide by 30 feet long and 1 foot deep, requiring the removal of about 32 yards of stone. These stones, with about

28 yards additional and with 60 yards of fascines, should be used in extending existing dam at △ C, both above and below, as shown, and in closing up crest of ledges adjacent to "*c*" and "*d*." The ledge at "*h*" should be lowered by the removal of about 32 yards of stone. The old dam at "*g*" should be raised and extended about 40 feet, as shown, and the crest of Crib Ledge closed up for about 80 feet on left side of sluice. The crest of ledge just below "*h*" need not be raised. It would only be necessary to raise dam to left of "*i*" by about 0.5 foot and extend same about 60 feet above, as shown, and to build two dams at right of channel, each about 55 feet long. For the dams on and adjacent to these two ledges, about 225 yards of fascines and 100 yards of stone would be required. Stone taken from channel and built into dams will cost here $7 per yard. The balance necessary, about 53 yards, could be obtained from adjacent ledges of high rocks and put in place for $3 per yard.

The next obstruction is met with in Blue Jacket Ledges at 12¼ miles (see Detail No. 7). A cut here should be made 20 by 20 by 1 foot, requiring the removal of 24 yards of stone. This stone used to raise the crest of adjacent ledge, would cost not to exceed $6 per yard in place.

At Little Harvey's Falls, at 8⅔ miles, two bowlders are met with in channel (see Detail No. 6). They are about 6 by 8 by 2 feet each, and could be broken up and used on crest of ledges near, at an expense of not more than $55 (11 yards at $5). The fall here is not heavy and much closing of ledge is unnecessary. At this point the overhanging trees should be cut from island for a distance of about 500 feet.

At 7¼ miles (see Detail No. 5), a rock ledge should be cut through requiring the removal of about 8 yards of stone at a cost of not more than $5 per yard.

The next bad place is at Pine Long Shoals, at 5½ miles (see Detail No. 4). Without any great outlay the channel near center of river could be improved and the dangerous pass at Whirligig abandoned. The channel here shows now about 1.7 or 1.8 feet at low water. The point of rock on right of channel above △ M (see Subdetail), should be cut off; the pass through ledge should be deepened at four or five places, and two or three bowlders removed near "*g*." In all, about 35 cubic yards of rock should be removed. The dam on the left of channel should be raised about 1.2 feet for 80 feet, requiring the use of about 20 yards of rock. The remaining rock taken from channel should be used on crest of ledge adjacent. The old pass at Whirligig should be closed by the use of 80 yards of stone and 150 yards of fascines. This stone could be obtained by blowing off points of ledge more than 0.5 foot above low water, from ledges at right bank and from one-fourth of a mile below, at a cost of $3 per yard. The rock excavated from channel would cost in dams about $7 per yard.

The next shoals in order are in the Four-Mile Reach. At 4.6 miles the channel passes among the upper three pairs of dams—see Detail No. 3 at "*b*" to "*g*." Below this the channel strikes into the river. Returning toward the left bank it passes the outer end of old dams at "*d*" and "*h*," and passing between the dams at "*m*," "*p*," and "*q*," it again strikes into river and passes through Half-Way Ledge midway between banks. The old channel through dams at "*d*" and "*h*," and among all dams from "r_1" down has filled with sand and has been abandoned. At "f_2," "g_2," and "h_2," the sand in old channel shows up at low water. Boats coming up and drawing not more than 1.2 feet may pass around Half-Way Ledges among dams in old channel as shown in dotted line. The dams in this reach are in fairly good condition, but, as I have stated before, all dams below "*e*" were improperly placed. The construction of many dams does not now seem necessary. This reach is, however, subject to such great changes that any system of improvement which may now seem the best may not be so at the time any improvement may begin. Were it possible to secure a channel through this reach only by the construction of dams, I should place all dams below the ledges opposite "*d*" upon the opposite side of the river. It may yet be necessary to do so. In general, pretty good water can be found in center of river.

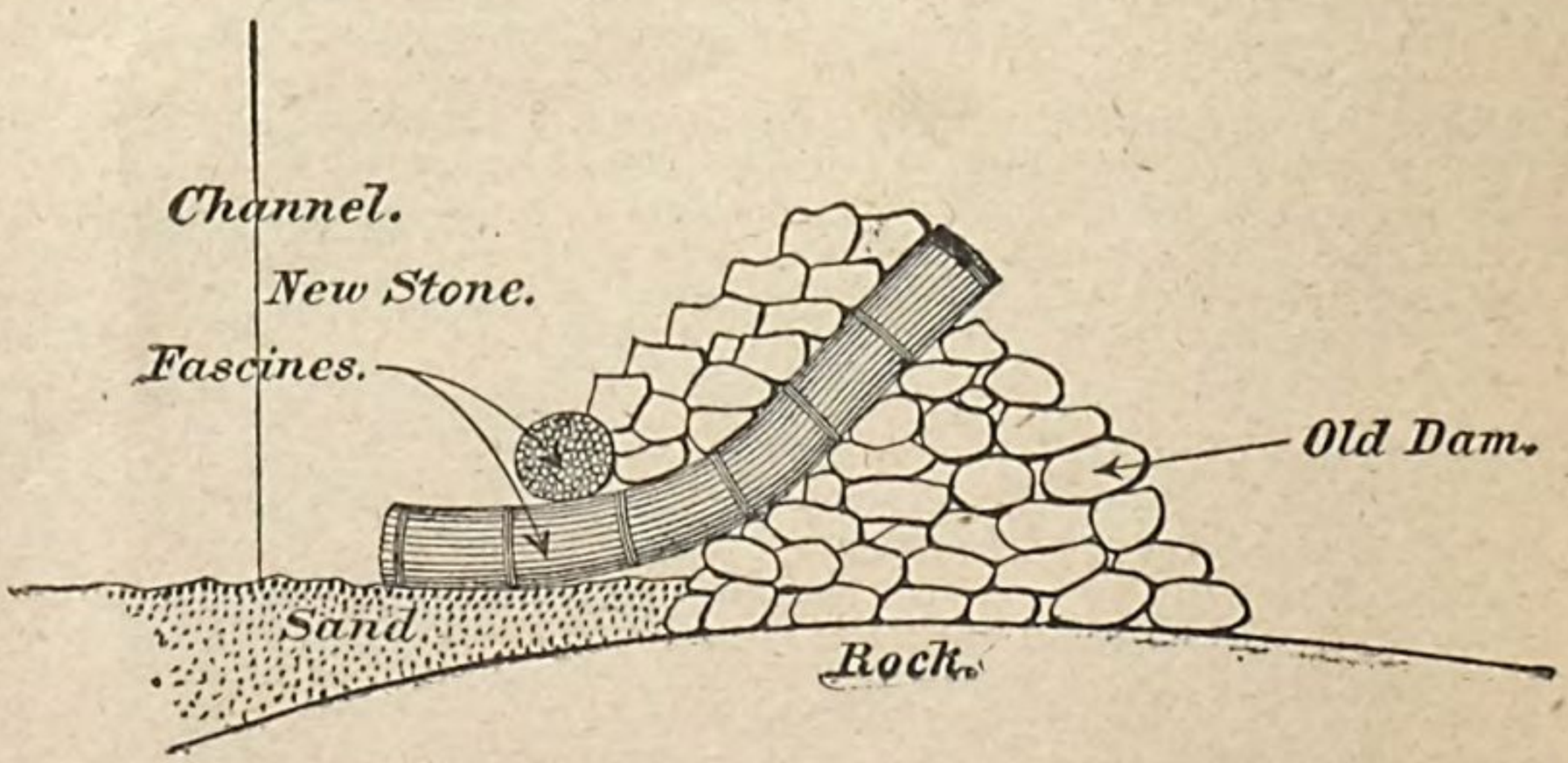
The objection to running there with loaded boats is that the channel is full of isolated ledges and bowlders which it is impossible to be certain of avoiding. The current is, however, not strong at or near low water, and with care boats could "hunt" a channel without much danger or loss of time. To improve the river as it now exists I should gather more water by the dams at "*c*," "*e*," and "*f*," in order to sooner wash out the sand deposited near "*g*" at high rivers. The dam to the right of "*c*" should be raised to about .5 foot above low water and extended at this height for about 120 feet. The two dams to the right of channel at "*e*" and "*f*" should also be raised, and the lower one extended about 40 feet as shown. The ledge at "*d*" should be blown out, requiring the removal of about 20 cubic yards of rock. A dam to left of channel should be built at "*g*," about 100 feet long in about 2.5 feet of water. For this work 370 yards of fascines and 80 yards of stone in addition to that blasted from ledge will be required. The rock taken from ledge will cost in place about $5.50 per yard. The remainder can be obtained one-half of a mile above and put in place at a cost not to exceed $2.50 per yard. At "$q_1$" every high river fills channel with sand. At every low river it is washed out, but not until after water

gets too low to allow boats to pass the adjacent ledge. Considering that a long dam at "n_1" already exists I am of the opinion that it would be worth the experiment to build a dam at the left of "q_1" as shown on Detail. The dam should be 180 feet long and would require about 150 yards of fascines and 40 yards of stone. The stone would come from above and would cost not to exceed $3 in place. Half-Way Ledge (see also Detail No. 3) has only about 1.3 feet at low water. Improvement could be readily effected by the removal of about 20 yards of rock in the shoal place below "r_2," by raising dams as shown, by about .8 foot and extending both as shown on Detail, both above and below. For this work about 175 yards of fascines and 120 yards of stone would be needed. The 70 yards of stone excavated would cost in dams about $7 per yard and the remaining 100 yards about $3 per yard.

The next obstruction is met with just below Bush Rock Ledge at 2½ miles; see Detail No. 2. This shoal only exists at the beginning of low water before the sand-bar formed at "*a-a-a*" by high water has washed out. At all times a good channel exists upon the opposite side of the river, substantially as shown. As it must be reached, after having passed Bush Rock, by crossing the river at right angles to current it is not in great favor among pilots. Loaded boats after passing down old channel under supposition that bar at "*a-a*" has washed out are often obliged to go back and passing under Bush Rock cross the ledge near right bank. This place might be improved by building training-wall as shown on Detail, about 500 feet long and requiring 500 yards of fascines and 100 yards of stone. As a channel always exists nearer right bank, as above stated, this improvement is not recommended.

The one remaining obstruction is Steven's Creek Falls—see Detail No. 1. A tortuous channel among the Ninety-nine Islands has been used since the building of the present dam at The Locks. The channel cut in 1883 through the falls proper, near right bank, as shown in Detail, has never been used by the pilots. Soundings were taken by myself through this cut and along route leading to same. Sufficient water is found in cut proper, but the passage to it from the channel above is very tortuous and without clearly marked boundaries. The channel is often at right angles to the river, and in many places is very shoal. The fall through the ledge is very heavy and abrupt.

Even were this channel used the building of a training-wall to the right of the channel at foot of the falls would be ne essary. Running this channel (if possibly one could be found among so many shoals at the head) would at least be dangerous. I would recommend the improvement of the channel among the islands. It should be done as follows: Excavate channel through ledge of Steven's Creek Falls at "*v*." Channel should be 15 feet wide. Take out from channel between "*j*" and "*m*" about 30 yards of loose bowlders and scattering ledges. Remove loose stone from channel at "*w-x*." Make a cut at "a_1-b_1" about 75 feet long by 15 feet wide by .9 feet deep. From "*i*" about 25 yards should be removed; from "*j-m*" 30 yards; from "*w-x*," 20 yards, and from "*a-b*" 60 yards; total, 135 yards. Raise dam at △ 7 by about 6 feet, and extend same about 120 feet, as shown. For this work, 215 yards of fascines and 75 yards of stone will be required. Two dams about 20 feet long each between the islands opposite "*k*" should be made, using 25 yards of fascines and 10 yards of stone. The following old dams should be raised. Those just above point 8, at the right, should be raised 1.5 feet and those to the left of "*r*," "*s*," "*t*," "*u*," "*v*," and "*w*" about .8 foot. The dam opposite "*x*" should be strongly rebuilt to about .5 foot above low water and the dam to the left of "d_1" repaired. About 350 feet of dams on crest of ledge and bordering cut at "a_1 b_1" should be made. On the dam to be repaired and raised short fascines should be used and laid as shown to make dam water tight.



Repairing the old and building the new dams mentioned (below "*l*") will require 425 yards of fascines and 180 yards of stone. The excavated rock placed in dams will cost $7 per yard. The remaining 130 yards of stone necessary can be obtained on the right bank above, and put in place at a cost of about $2.50 per cubic yard. From right of channel at "*v*," a log should be taken which is now in way of boats. Between "*s*" and "*x*" the right bank should be trimmed for 400 feet.

Going up stream the boats, when possible, seek the stillest water, found usually close to the bank. In many cases the boats are prevented by willows and snags from running close to shore. In some of these cases it would be advantageous to trim the banks and remove the worst snags. On the survey it was not possible to note all places where such clearing should be done, from the fact that the river was then seen at low water only, while those obstructions offered to boats going up are mainly felt at high water. Through most of the ledges narrow passes are found through which the light boats coming up can easily pass. In the heavier ledges, where no such passes occur, and where boats are now obliged to go up through main sluice, navigation would be greatly benefited by cuts. In all such cuts as for those of down channel the crest of the ledges should be closed to low water, as far as may be, by the excavated material.

Besides cutting overhanging trees no work is necessary on an up channel until the foot of Scott's Shoals is reached. Here at 14.6 miles a log should be taken out.

Through Paunel's Ledges at 20.5 to 20.7 miles three cuts 10 feet wide should be made near the right bank. From these cuts about 45 yards of stone should be taken.

At 21 miles a log should be taken out and the trees cut from bank for about 300 feet.

At 22.8 miles a cut should be made through Price's mill-dam. This cut will require an excavation equivalent to about 20 yards of rock.

At 23 miles 25 cubic yards of rock should be removed from ledge.

At 23.1 miles three bowlders of about 2 yards each—total 6 yards—should be removed.

At 23.3 a pass should be cut through lower Chamber's Ledge. In all about 35 yards of rock should be removed.

At 23.5 about 35 yards should be taken out in two cuts.

A cut through Elbow Gap Ledge at 23.8 miles should be made and 45 yards of rock taken out.

Through Gar Hole Ledge at 24 miles, a cut should be made from which 10 yards should be removed. At Bush Rock just above, a cut of about 60 yards is necessary.

Through Heart of Stuman at 24.5 miles, a cut of about 55 yards should be made.

At 24¾ miles, a cut in upper ledge of Stuman would yield 40 yards of stone.

At Sandy Landing, 25.2 miles, a single rock of 2 cubic yards should be removed.

From near the right bank at 26½ miles, three bowlders should be removed, about 8 yards.

At 26.3 miles about 20 yards should be removed from near Bussey's old dam.

No other excavation for up channel is now known to be necessary. It is probable that in addition to the cutting of trees mentioned, 5 miles of banks should be cleared. A laborer at $1 per day should clear up 200 feet. At any rate, the work should not cost more than $35 per mile, or in short sections, 1 cent per foot.

The rock excavated for an up-channel is in shoaler and stiller water than is found near down-channel. Five dollars might be taken as a reasonable figure for the excavating and placing of this material.

The cost of fascines on this work should not be more than 75 cents per cubic yard. Considering the small amounts necessary at each place it might be safer to estimate fascines at $1 per cubic yard.

It should be remarked that in these estimates the quantity of rock excavated is taken at 160 per cent. of the cubic contents of the excavation. Rock in ledges weighs about 4,000 pounds per cubic yard. Excavated rock piled for measuring will weigh about 2,500 pounds per cubic yard.

The following is a tabulated list of the obstructions met with between the Locks and Petersburg, on the Savannah River, together with a detailed estimate of cost of improving channel for pole-boats through them:

Detailed list of obstructions and cost of improving the same—Petersburg to The Locks—Savannah River.

Number.	Number of the detail.	Number of sheet of detail.	Shoal.	Distance from The Locks.	Length of the obstruction.	In down or up channel.	Least water in channel at low water.	Fall for distance given.	Improvement recommended.							Miscellaneous remarks.
									Number of cubic yards of excavation required.	Cost of excavation, including replacing of stone.	Yards of additional stone required on dams.	Cost of additional stone.	Cost of fascines required in dams at $1 per cubic yard.	Length of bank to be trimmed.	Cost of trimming banks.	
				Miles.	*Feet.*			*Feet.*						*Feet.*		
1	1	1	Stevens' Creek Falls	1	1,600	Both	1.5	3.6	135	$945	130	$325	$665	400	$4	One log to be removed.
2	3	2	Four-Mile Reach	3.5	6,500	do	1.3	3.0	40	250	220	620	690			
3	4	3	Pine Log Shoals	5.5	250	Down	1.7	1.3	35	245	80	240	150			
4	5	3		7.25	15	do			8	40						
5	6	3	Little Harvey's Falls	8⅔	125	do			11	55				500	5	
6	7	3	Blue Jacket Ledges	12.25	200	do	1.0	0.6	24	144						
7			Foot Scott's Shoals	14.6		Up										One log to be removed.
8	8	3	Scott's Shoals	14.75	1,000	Down	1.3	2.7	64	448	96	288	285			
9	9	3	Chicken Sluice	15.5	1,500	do	1.6	2.1	60	300	50	150	220	1,100	11	
10	10	4	Little River Shoals	17.25	600	do	1.5	3.3	192	1,278	40	100	320			
11	11	5	Foot of Crow Hill	18	800	do	1.7	0.6	30	150	100	300	350	1,200	12	
12	12	5	Garden Shoals	20	200	do	1.4	1.3	81	567			40			
13			Pannel's Ledges	20.6		Up			45	225						A cut through three ledges.
14	13	5	do	20.75	1,200	Down	1.3	4.4	183	1,190	77	192	305			
15				21	300	Up								300	3	One log to be removed.
16			Spring Ledge	21.5	20	Down			75	450			40			
17			Morgan's Ledges	21.8	300	do								300	3	
18	14	6	Cold Rain Ledge	22.75	400	do	1.5	2.1	23	161	37	111	40			
19			Price's Mill Dam	22.8	20	Up			20	100						
20				23	20	do			25	125						
21				23.1		do			6	30						
22			Chamber's Ledge	23.3		do			35	175						
23				23.5		do			35	175						
24			Elbow Gap Ledge	23.75		do			45	225						
25	15	6	Elbow Gap	23.75	300	Down	1.8	1.3	107	642			80			
26	16	6	Dordon Creek Shoals	24.1	800	do	0.9	4.4	214	1,498			285			
27			do	24.1	800	Up			70	350						
28			Heart of Stuman	24.5	80	do		1.1	55	275						
29	17	7	do	24.5	80	Down	1.2	1.1	40	300	30	75	50			
30			Stuman Ledges	24.75		Up			40	200						

31	.....	.....	.....	25.2	.....	..do....	.....	.....	2	10	.....	.....	.....	.....	.....	
32	18	7	Indian Jaw.....	26.2	200	Down...	1.3	2.8	80	600	.....	.....	60	.....	.....	
33	.....	.....	.....	26.25	.....	Up.....	.....	.....	8	40	.....	.....	.....	.....	.....	
34	.....	.....	.....	26.3	.....	..do....	.....	.....	20	100	.....	.....	.....	.....	.....	
35	19	7	Point Lookout Shoals	28.5	100	Down...	1.3	0.9	18	90	18	54	120	700	7	
36	.....	.....	Grey Horse Ledge.....	29.2	300	...do....	.....	.....	.....	.....	.....	.....	.....	300	3	
37	.....	.....	Howe's Creek Ledge.....	30.3	500	...do....	.....	.....	.....	.....	.....	.....	.....	500	5	
38	.....	.....	.....	32.8	600	...do....	.....	.....	.....	.....	.....	.....	.....	600	6	
39	.....	.....	.....	35.75	800	...do....	.....	.....	.....	.....	.....	.....	.....	800	8	
40	20	7	Barksdale Ferry Ledge.....	37.5	100	...do....	1.6	0.6	64	448	16	48	40	.....	.....	
41	.....	.....	.....	39.9	.....	...do....	.....	.....	.....	.....	.....	.....	.....	100	1	
42	.....	.....	Miscellaneous	.....	.....	Up.....	.....	.....	.....	.....	.....	.....	.....	.....	175	5 miles of willows to be cut.
			Total	.....	.....	.....	.....	.....	1,890	11,831	894	2,503	3,740	6,800	243	

SUMMARY.

Excavation, 1,890 yards, at $6.25 (deduced mean)	$11,831
New stone, 894 yards, at $2.80 (deduced mean)	2,503
Fascines, 3,740 yards, at $1	3,740
Clearing banks, 6.27 miles, at $38.63 (deduced mean)	243
Removing logs, three logs, at $5	15
Total	**18,332**

As nearly as may be determined the estimates of quantities under the recommended project above are liberal. The prices given upon the work are sufficiently ample to enable a contractor to purchase and pay for necessary plant, and to realize a good profit from the venture.

The following is the mean basis of my figures on the stone-work:

Rock excavation, per yard	$4.76
Placing excavated rock on dams, per yard	1.50
New riprap stone, per yard	2.80

The first work done by the General Government on this part of the river was done in 1881 and 1882 by Mr. Blaisdell, under contract of October 16, 1880. The following prices were paid for the work:

Rock excavation, per cubic yard	$4.50
Gravel excavation, per cubic yard	.32
Riprap stone, per cubic yard	2.60

Under the next appropriation, that of 1882, Mr. Blaisdell made the following bid upon the work:

Rock excavation, per cubic yard	$4.50
General excavation, per cubic yard	.35
Riprap stone per cubic yard	2.75
Mattresses, per square yard	.85

In view of the fact that Mr. Blaisdell offered these figures after having had two years' experience upon this river, we may safely assume these figures to be reasonable. The work done under the appropriation of 1882 was done by Mr. W. H. Brown, under contract of January 5, 1883, at the following prices:

Excavation of rock, per cubic yard	$4.320
Excavation of gravel, per cubic yard	.310
Riprap stone, per cubic yard	2.315
Mattresses, per square yard	.925

Upon my estimate 1,890 yards of excavation and 2,744 yards of riprap stone are required, at a total cost of $14,334. These quantities under the contract of January 5, 1883, about $14,517, or about $180 above the figures I have given. When it is remembered that less than 40 yards of the excavated rock is not again used, it will be seen that my figures for this work are lower than even those of the lowest previous contract, where much of the stone removed was not again used.

From my figures the improvement of the up-channel will cost $2,213, or only abont 12 per cent. of the total amount. Of the total amount all but $1,000 would be expended below the head of Long Shoals, or within the region affording about two-thirds of the freights.

The total cost of improving the Savannah River between Petersburg (or practically the foot of Trotter's Shoals) and The Locks, above Augusta, for a pole-boat channel 2 feet deep for boats going down, and 1.3 feet deep for boats going up, of a sufficient width in both cases will be as follows:

Rock excavation	$11,831
New riprap	2,503
Fascines	3,740
Clearing banks	243
Removing logs	15
	18,332
Contingencies, 25 per cent	4,583
Total	22,915

* * * * * * *

It was estimated upon my report in the examination of the river in 1888 (see report dated February 11, 1889), that the annual commercial value of the Savannah River for the territory included within the present report was $9,319. Thus we see that an outlay of $22,915 by the General Government will save to the planters nearly $10,000 per year. As a purely business venture this outlay would bring in a permanent income of about 40 per cent.

As the boating is now done above Augusta, the cotton handled is often wet during the trip. If a boat "grounds," the cotton is often thrown overboard, tied together and rafted for a greater or less distance. This is so often done that the handling of up-river cotton is in great disfavor among the cotton factors of Augusta. From wet

cotton large deductions are always made to the prejudice of all parties. The improvement recommended would remove the cause of prejudice and restore confidence in the produce of this region.

GEO. W. BROWN,
Assistant Engineer.

Lieut. O. M. CARTER,
Corps of Engineers, U. S. A.

O 14.

ESTABLISHMENT OF HARBOR LINES OF FERNANDINA HARBOR, FLORIDA.

FERNANDINA CHAMBER OF COMMERCE,
Fernandina, Fla., March 5, 1890.

SIR: The Chamber of Commerce of this city respectfully represents that a necessity exists for the establishment of harbor lines in this port. Shipping is largely increasing here and wharves are being built without regard to harbor-lines, with a result most injurious to the harbor.

Your attention is respectfully called to these facts and we ask that such action be taken as will cause said harbor-lines to be determined at an early day.

Respectfully,

H. E. DOTTERER,
President.

Attest:

WILLIAM R. KEELY,
Secretary.

Lieut. O. M. CARTER,
Corps of Engineers, U. S. A.

[First indorsement.]

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., March 22, 1890.

Respectfully submitted to the Chief of Engineers, U. S. A., Washington, D. C., through Colonel Wm. P. Craighill, Corps of Engineers, U. S. A., Division Engineer, Southeast Division, Baltimore, Maryland, with the recommendation that the request of the Fernandina Chamber of Commerce may be complied with.

O. M. CARTER,
First Lieutenant, Corps of Engineers.

[Second indorsement.]

UNITED STATES ENGINEER OFFICE,
Baltimore, Md., March 26, 1890.

Respectfully forwarded to the Chief of Engineers.

My own observation of the situation at Fernandina at a recent visit enables me to concur in the recommendation of Lieutenant Carter.

WM. P. CRAIGHILL,
Colonel of Engineers.

[Third indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
March 28, 1890.

Respectfully submitted to the Secretary of War.

It appearing from the within letter and the preceding indorsement thereon that the establishment of harbor-lines in the harbor of Fernandina, Fla., is essential to its preservation, it is recommended that a board of engineers to consist of Colonel W. P. Craighill, Major H. M. Adams, and Lieut. O. M. Carter, Corps of Engineers, be constituted to meet at Fernandina, Florida, at the earliest practicable time, to consider and report on the subject of proper harbor lines at that place with the view to the establishment of such lines by the Secretary of War, under authority of section 12 of the act of August 11, 1888. With your approval the order for the board will be issued from this office.

THOS. LINCOLN CASEY,
Brig Gen., Chief of Engineers.

[Fourth indorsement.]

WAR DEPARMMENT,
April 1, 1890.

The recommendation of the Chief of Engineers is approved.
By order of the Secretary of War.

JOHN TWEEDALE,
Chief Clerk.

REPORT OF BOARD OF ENGINEERS.

SAVANNAH, GA., *April* 25, 1890.

GENERAL: The Board of Engineers constituted by Special Orders No. 16, Headquarters Corps of Engineers, Washington, D. C., April 2, 1890, for the purpose of establishing the harbor-lines of Fernandina harbor, met at Fernandina, Fla., on April 23, 1890, all the members being present. With a view to allowing wharf-owners and other interested persons to be present at the meeting the following notice had been posted in conspicuous places in the city of Fernandina and published in both of the local papers:

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., April 10, 1890.

Notice is hereby given that the Secretary of War has constituted a Board of Engineers to establish the harbor-lines of Fernandina Harbor, in accordance with section 12 of the river and harbor act of August 11, 1888. A public meeting of this Board will be held at Fernandina, Fla., on April 23, at 12 o'clock. Those who have any matter which they desire to be submitted to the Board are requested to be present at this meeting.

For further information address

O. M. CARTER,
First Lieut., Corps of Engineers.

In response to this notice a number of persons, among them members of the city council and pilot commissioners, representing all interests concerned in the location of the harbor-line, appeared at the meeting. The Board, having conferred with the persons present and having

examined the harbor and the data relating to the same collected by the local engineer, has the honor to submit the following report:

The harbor of Fernandina is that portion of Amelia River between its junction with Lanceford Creek and the entrance into Cumberland Sound. In view of the fact that no demand will probably be made in the near future for the establishment of wharves which would interfere with the navigable channel elsewhere than along the city front, the Board has limited its work to the consideration of harbor-lines in that locality.

Considering the expense to which owners would be put to remove existing wharves, as well as the necessity for preventing further encroachments upon the harbor, the Board submits, with recommendation for approval, the line indicated on the tracing herewith and hereinafter more fully described, as one found at the public meeting before mentioned to be satisfactory to all interested persons, and as one which will probably give results well suited to the preservation of the harbor and at the same time cause no injury to existing wharf property.

DESCRIPTION OF FERNANDINA HARBOR-LINE.

The harbor-line is determined by eleven points numbered from one to eleven on the map accompanying this report, the line between each two adjacent points being straight. The following is a description of the location of these points, the first nine of them being referred to the center line of Front street and the intersection of the same with the center line of Centre street, and the last two of them being referred to the center line of Sixth street and the intersection of the same with the center line of Loon street.

Description of point No. 1.—From the intersection of the center line of Centre street and the center line of Front street measure 2,933 feet along the latter, southward, and from the point thus reached measure 1,732 feet, at right angles to the center line of Front street and westward, to point No. 1.

Description of point No. 2.—From the intersection of the center line of Centre street and the center line of Front street measure 1,915 feet along the latter, southward, and from the point thus reached measure 972 feet, at right angles to the center line of Front street and westward, to point No. 2.

Description of point No. 3.—From the intersection of the center line of Centre street and the center line of Front street measure 840 feet along the latter, southward, and from the point thus reached measure 540 feet, at right angles to the center line of Front street and westward, to point No. 3.

Description of point No. 4.—From the intersection of the center line of Centre street and the center line of Front street measure 505 feet along the latter, northward, and from the point thus reached measure 140 feet, at right angles to the center line of Front street and westward, to point No. 4.

Description of point No. 5.—From the intersection of the center line of Centre and the center line of Front street measure 965 feet along the latter, northward, and from the point thus reached measure 159 feet, at right angles to the center line of Front street and westward, to point No. 5.

Description of point No. 6.—From the intersection of the center line of Center street and the center line of Front street measure 1,530 feet along the latter, northward, and from the point thus reached measure 250 feet, at right angles to the center line of Front street and westward, to point No. 6.

Description of point No. 7.—From the intersection of the center line of Center street and the center line of Front street measure 2,281 feet along the latter, northward, and from the point thus reached measure 160 feet, at right angles to the center line of Front street and westward, to point No. 7.

Description of a break in the center line of Front street.—From the intersection of the center line of Centre street and the center line of Front street measure 2,345 feet, more or less, along the latter, northward, to the intersection of the center line of Front street, with the northern side of Escambia street, Front street at this point making an angle of 31° 30″ with its former direction.

Description of point No. 8.—From the above described break in the center line of Front street measure 860 feet along the latter, northeastward, and from the point thus reached measure 260 feet, at right angles to the center line of Front street and northwestward, to point No. 8.

Description of point No. 9.—From the above described break in the center line of

Front street measure 1,580 feet along the latter, northeastward, and from the point thus reached measure 210 feet, at right angles to the center line of Front street and northwestward, to point No. 9.

Description of point No. 10.—From the intersection of the center line of Loon street and the center line of Sixth street measure 249 feet along the latter, northward, and from the point thus reached measure 150 feet, at right angles to the center line of Sixth street and westward, to point No. 10.

Description of point No. 11.—From the intersection of the center line of Loon street and the center line of Sixth street measure 1,172 feet along the latter, northward, and from the point thus reached measure 147 feet, at right angles to the center line of Sixth street and westward, to point No. 11.

Seventy feet to the southward of point No. 11 the harbor-line is intersected by the southern boundary line of the Fort Clinch military reservation.

The Board recommends that if the proposed harbor-line be approved a copy of this report, including the chart showing the harbor-line, be placed in the hands of the authorities of the city of Fernandina, with the request that the latter adopt such measures as may be necessary to secure compliance therewith.

WM. P. CRAIGHILL,
Colonel, Corps of Engineers.
H. M. ADAMS,
Major, Corps of Engineers.
O. M. CARTER,
First Lieut., Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

[First indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
May 8, 1890.

Respectfully submitted to the Secretary of War.

It appearing that the establishment of harbor-lines of Fernandina, Fla., is essential to the preservation and protection of that harbor, the Secretary of War, by indorsement of April 1, 1890 (paper herewith), approved the recommendation of this office that a Board of Engineers be constituted to consider and report on the subject of proper harbor-lines at that place, with the view to the establishment of such lines by the Secretary of War, in accordance with the provisions of section 12 of the act of August 11, 1888.

The Board constituted under this authority, having given the subject careful consideration, submits the within report and accompanying tracing, on which the proposed lines for the harbor of Fernandina are drawn.

It is recommended that the lines selected be approved, and that the Secretary place his approval both upon the report and upon the tracing submitted.

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

[Second indorsement.]

WAR DEPARTMENT,
May 9, 1890.

Approved

REDFIELD PROCTOR,
Secretary of War.

APPENDIX P.

IMPROVEMENT OF CERTAIN RIVERS AND HARBORS IN THE STATE OF FLORIDA.

REPORT OF CAPTAIN WILLIAM M. BLACK, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1890, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. St. John's River, Florida.
2. Volusia Bar, Florida.
3. Harbor at St. Augustine, Florida.
4. Northwest entrance, Key West Harbor, Florida.
5. Caloosahatchee River, Florida.
6. Pease River, Florida.
7. Manatee River, Florida.
8. Tampa Bay, Florida.
9. Withlacoochee River, Florida.
10. Harbor at Cedar Keys, Florida.
11. Suwanee River, Florida.
12. Removing sunken vessels or craft obstructing or endangering navigation.

EXAMINATION AND SURVEY.

13. Sarasota Bay, Florida.

UNITED STATES ENGINEER OFFICE,
Saint Augustine, Fla., July —, 1890.

GENERAL: I have the honor to transmit herewith my annual reports upon the works of river and harbor improvement under my charge for the fiscal year ending June 30, 1890.

Very respectfully, your obedient servant,

W. M. BLACK,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

P 1.

IMPROVEMENT OF ST. JOHN'S RIVER, FLORIDA.

The portion of the river under improvement from Jacksonville to the ocean may be divided into four reaches, as follows:

1. Jacksonville to Dame's Point: Length, 12.4 miles; average channel width between 20-foot contours 1,100 feet, between 15-foot contours 1,300 feet; minimum 15-foot channel width 550 feet; minimum mid-channel depth 20 feet; mean range of tide 1.2 feet.

2. Dame's Point to Beacon No. 1 (1 mile below St. John's Bluff): Length 7.5 miles; aggregate length of channels less than 15 feet deep, 1.3 miles; average width of these channels between 9-foot contours 850 feet; minimum width between 9-foot contours 400 feet; minimum mid-channel depth of defective portions 12.5 feet; minimum mid-channel depth of remainder of reach 15 feet; range of tide 2.15 feet.

3. Beacon No. 1 to mouth: Length 5 miles; average width between 20-foot contours 700 feet; between 15-foot contours 870 feet; minimum mid-channel depth (except at one place 1 mile long) 20 feet; depth at excepted place 15 feet; range of tide 3.41 feet.

4. Mouth to outer bar: Distance 2.5. miles. Before the improvement was begun this was crossed by shifting channels from 2.1 to 2.5 miles long and having a mean low-water depth of from 5 to 7 feet. The tidal range on the outer bar is 6 feet. The channel over the bar is now nearly straight, permanent in position within slight limits and has a least mean low-water depth of 11.5 feet. Between the mouth and the bar the present ship channel follows close to the south jetty. It is obstructed by a bulkhead shoal at its inner end, which will be avoided by the permanent jetty channel.

PROJECT OF IMPROVEMENT.

The operations for improving this channel have been carried on in accordance with a project submitted to the Chief of Engineers, June 30, 1879, by the late General Q. A. Gillmore, colonel, Corps of Engineers, and printed as part of Appendix I 7, Annual Report of the Chief of Engineers for 1879.

The approved project is to obtain a least mid-channel depth of 15 feet at mean low water from Jacksonville to the ocean. This depth is to be obtained across the bar at the mouth by concentrating and directing the flow of the river by two long jetties starting from opposite sides of the entrance and converging until near their outer extremities on the bar they shall be 1,600 feet apart. The jetties are to be built of mattresses of log or brush and riprap and suitably capped. No detailed project for the improvement of the defective reaches of the river has yet been adopted. General Gillmore's estimate of the cost of the entire improvement is $1,426,409.

OPERATIONS PRIOR TO JUNE, 1889.

Six appropriations have been made for this improvement aggregating $850,000,000. Of these the first five were for improving the channel over the bar at the mouth only. The last was made available for the complete project. The work was done almost entirely by contract, as funds were available. On June 30, 1889, the progress of the jetty construction was as follows:

South jetty.—Total length of foundation course, 6,667 feet; length of superstructure with crest at mean low water, 4,100 feet. This contained 203,063.6 square yards of mattresses, 72,486.8 cubic yards of stone, and 893 cubic yards of oyster shells.

North jetty.—Total length, including shore extension, 8,040.2 feet. Of this 553 feet was built to full height and capped; 6,144 feet was built to the level of mean low water, and 1,343.2 feet was the mattress foundation-course.

In the construction of the jetty there had been used 84,581 square

yards of mattresses, 58,635.5 cubic yards of stone; 3,831.4 cubic yards of oyster shells, and 286.5 cubic yards of concrete.

The field work for a survey of the defective reaches near Dame's Point had been completed.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

Jetty work under the contract with Mr. R. G. Ross was continued until October 30, when the available funds were exhausted, 13,000 square yards of brush-mattresses, 15,118.2 tons (2,000 pounds) of stone and 1,493.71 cubic yards of shells were placed in the north jetty, extending its foundation length 1,007.9 feet, and its riprap superstructure with the crest at mean low-water level 18 feet wide, 700 feet and with the crest at mean low water and 8 feet wide, 290 feet further, 3,896.4 tons (2,000 pounds) of stone, and 492.67 cubic yards of oyster shells were placed in the south jetty superstructure, filling gaps in the old work, caused by the loss of logs from the mattresses, and advancing the superstructure with a narrow crest at mean low water 800 feet. Two thousand one hundred and thirty-six and eight-tenths tons of stone and 1,495.16 cubic yards of shells were placed on shore under the contract, on the shore extension and wings.

The remaining work of the year included partial surveys made from time to time, the construction of the shore extension of the south jetty back to the sand hills at Station 480, building the jetty to full height as far as Station 1254 and capping a small area at the angle of the north jetty (Station 6470). All of this work was done by hired labor, using materials bought by contract or in open market, as was most economical and advantageous to the United States.

DAME'S POINT SURVEY.

For details of the work of this survey, attention is invited to the appended report of Mr. J. H. Bacon, assistant engineer. The survey was made as accurate and complete as possible, in order that future effects of the jetties on the regimen of the stream could be observed, as well as to give a basis for the projected improvement of this defective reach. The work comprised surveying and mapping the defective reach of the river, 10 miles long, and the low neck of land to the north of Dame's Point; gauging the stream at two cross-sections near the upper and lower ends of the reach; making observations for current velocity and direction at ten fixed stations outside the sections; observing and plotting the courses of movable floats; determining character of bottom by borings; observations for sediment at various depths, and observations of tidal phenomena.

General characteristics of reach.—On Plate 2 it will be noted that the shoals in the ship channel having less than 20 feet of water in them are (1) opposite Dame's Point; (2) at Alligator Pass; (3) opposite the mouth of St. Charles Creek; (4) below the mouth of Brown's Creek, and (5) just above Great Marsh Island. The aggregate length of these shoals is 1.3 miles, and the least depth over them is 12.5 feet, with a tidal range of 1.6 feet. It will also be seen that there is a deep channel on the right bank from Pauline Island to Fulton, with shoals off Mill Cove Point and above Fulton. Caving banks of sandy clay are found on the left bank from Dame's Point to St. Charles Creek and on the right bank at St. John's Bluff. At the latter place the erosion in recent years has been very great. A comparison of the chart of the

recent survey with United States Coast Survey Chart No. 454 (dated 1856) shows that there has been but little change in the position of the channels; that they are somewhat deeper now, and that one new island has been formed on the shoals off the mouth of Clapboard Creek.

Tidal phenomena.—In the absence of a line of levels connecting the gauges, the relative height of their zeros was obtained by simultaneous reading of contiguous gauges during high and low water slack. This method gives results sufficiently accurate for the purpose. The results of the observations are tabulated in Plate C. The difference in tidal range at the two ends of the reach is 1.04 feet. At Dame's Point the ebb currents continue for 5 minutes longer and the flood for 28 minutes 2 seconds less time; the mean ebb stage is 0.09 higher and the mean flood stage 0.41 lower than at St. John's Bluff.

Currents.—As reduced for a mean range of tide, the flood currents at St. John's Bluff have mean velocities varying in the different sections from .9 to. 98 feet per second, and at Dame's Point from .58 to .96 feet per second; during ebb the mean velocities in the different sections vary from .68 to 1.73 feet per second at Dame's Point, and from 1.05 to 2.24 feet per second at St. John's Bluff; the maximum mean velocities being 1.58, 1.58, and 2.4 and 3.52 feet per second respectively, all as might be expected from the comparative cross-sections.

In general, in the deeper portions of the reach the directions of the ebb and flood currents are nearly or exactly opposite, and parallel to the axis of the channel; on the shoals the current directions form appreciable angles with each other. The current directions are nearly constant, changing only when the tide turns.

At Station No. 1 in the deep channel off St. John's Bluff flood begins at the bottom about 30 minutes before it begins at the surface, and continues there about 45 minutes after it begins to ebb at the surface. This was not noticed at Dame's Point, where there was frequently no slack water between tides, the current gradually changing from ebb to flood and *vice versa.* (Report of Mr. J. H. Bacon.)

Borings.—Forty borings were made at various points in the reach, with but two exceptions varying in depth from 20 to 30 feet. Rock was not found at any point. Clay was found in the channel near Reddie's Point. Everywhere else the river bottom was found to be made up of layers of mud and sand.

Projects for improvement.—From the chart it is evident that either the present ship channel or the Mill Cove channel would, if it were continuous, be large enough to satisfy the demands of commerce and that consequently it will not be necessary to consider a project for controlling the entire body of the river flow.

Three general plans for the improvement suggest themselves: 1. A ship channel across Dame's Point from Dunn's Creek to St. Charles Creek. 2. The improvement of the Mill Cove channel. 3. The improvement of the Dame's Point channel.

Ship Canal.—This would have to be at least 200 feet wide and 15 feet deep at mean low water, with revetted banks. The cut would extend from the deep water off the mouth of Dunn's Creek to the deep water between the mouths of St. Charles and Brown's creeks. The total length of the cut required is 15,250 feet, of which 12,500 feet is through land. The total volume of material to be dredged would be 2,700,000 cubic yards; 22,800 square yards of revetment would be required. Jetties would be needed at both ends to protect the canal against cross tides entering and leaving Dunn's and St. Charles creeks. The total estimated cost of this project is $825,000. Some shore protection would be required at St. John's Bluff in addition.

2. *Mill Cove Channel.*—This channel is traversed by the ebb flow close to Reddie's Point, the ebb spill across the flats west of Dame's Point and on the north side of Marian Island, and by a portion of the flood flow around Mill Cove Point from both channels. A practicable route for an improved channel 15 feet deep would be, going down the river, to cross from the present ship-channel in a line close to beacons 11, 9, and 7, to the west of Marian Island; thence to follow the deep channel close around Mill Cove Point to the south of Long Island. For this, dredging would be required at the Dame's Point Crossing, at Mill Cove Point, and near Fulton, and deflecting works at Dame's Point between Radcliffe and Long Islands and at Little Marsh Island, with slight shore protection at St. John's Bluff. The total amount of dredging required would be 501,000 cubic yards. The aggregate length of training-walls, 16,200 feet. The estimated cost is $290,000.

3. *Dame's Point Channel.*—A practicable route for this channel is to follow the present ship-channel to Alligator Pass, and thence to go through Alligator Pass and along the south shore of Long Island. Training-walls would be required off Dame's Point, at Alligator Pass, Long Island, and Little Marsh Island, with shore protection at St. John's Bluff. The total amount of dredging required to obtain a depth of 15 feet at mean low water would be 202,000 cubic yards, the aggregate length of training-walls, 13,500 feet. The estimated cost is $175,000.

JETTY CONSTRUCTION.

Mattresses, stone, oyster-shells.—These were all used as explained in the last Annual Report. The oyster shells were also used for chinking and compacting the stone foundations for the concrete blocks. Wherever used if exposed to strong current or wave action, they must be well covered and protected by stone.

Concrete coping.—As the inner end of the south jetty is not exposed to the heaviest wave action, it was built to the full height by a simple wall of concrete blocks 2 feet wide on top and from 18 inches to 2 feet thick, as shown in Plate E. Near Station 4, two of these blocks were moved during a heavy gale, apparently by undermining, the weight of the blocks being insufficient to hold the light riprap bed. Experience has shown that light riprap can not be held above the mean low-water line even as side slopes for heavy crest blocks. Accordingly on the most exposed portions of this coping the side slopes of the crest blocks were prolonged to mean low water by additional concrete blocks. At Station 6470 the north jetty was built to the full height with a crest 4 feet by 6 inches, and side slopes of 1 on 2. Here the coping was of concrete blocks 18 inches thick. The blocks of the side slopes were hexagonal in horizontal sections and had vertical sides. They weighed about 1,600 pounds each. These blocks were of convenient shape and were easily placed. The coping is too light. During heavy gales individual blocks have been displaced at times.

TIDES AND TIDAL FLOW.

The study of the tidal action at the mouth of the river was continued. A series of gauges was established inside and outside the jetties between the shore and the crest of the bar. The gauges were generally 3-inch iron pipes sunk in place by a water jet, and containing a float and staff. Great difficulty was experienced in connecting their zeros by level lines, but a comparison of the results obtained by the use of the surveyor's level, by observations of high and low water slack, and by

observations on the sea horizon corrected for dip, shows that their comparative levels as given on Plate G are correct to within 0.15 feet. The results of the observations given on Plate G are interesting, but the observations are not sufficient in number to permit any definite deductions to be made. They show the difficulty of deducing current velocities from the slope of the water-surface in tidal streams, particularly when these streams contain water varying in density. The observations for current direction and velocity are plotted on Plate F. The comparison of the current directions and velocities with the tidal curves shows the limit to which it will be necessary to raise the jetty crest in order to utilize the ebb currents to their full extent and also the slight danger of the movement of sand into the river by unaided flood currents.

Attention is invited to the observed differences of tidal range at the various gauges as shown on Plate G.

PRESENT CONDITION OF JETTIES.

South jetty.—This jetty has a total length of 7,147 feet, of which 1,740 feet (from Station 480 to Station 12160) is built to the full height and capped; for 2,740 feet more (to Station 4000) the crest is built to and above the level of mean low water. Thence for 800 feet it is at an average level of about 1 foot below mean low water. The crest of the remaining part of the jetty, 1,867 feet, averages about 5 feet below mean low water.

The condition of the jetty continues stable. Scarcely any lowering of the crest has taken place, except between Stations 4000 and 4800. This lowering (about 1 foot) is not due to underscour, but to the fact that the superstructure of this portion of the jetty, which was composed of a narrow ridge of riprap with very steep side slopes assumed a more stable slope under the joint action of waves and currents.

The stone of the older portion is well compacted and has been closely cemented together by shell-fish.

Owing to the narrow crest and steep side slopes of this jetty a considerable addition of material will be necessary before it can be built up to full height.

Up to date 203,063.6 square yards of mattresses, 77,849.6 cubic yards of riprap, 2,880,83 cubic yards of shell, and 218 cubic yards of concrete have been used in the construction of this jetty.

North jetty.—The total length of this jetty, including the shore extension, is 9,048 feet. Of this, for 553 feet (from Station 57 to Station 496) the jetty is built to the full height and capped; for 6,404 feet more (to Station 6900) the crest is built to and above the level of mean low water, except at a few places between Stations 800 and 2300, where the greatest distance of the crest below mean low water nowhere exceeds 2.5 feet. From Station 6900 to the end, the jetty is covered by from 1 to $5\frac{1}{2}$ feet of water at mean low water.

The average width of the crest out to Station 6900 is about 10 feet.

No evidence of underscour and consequent settlement is shown on any portion of this jetty. The lowering of the portion of the crest mentioned above is due to the action of the breakers.

The riprap on the older portions of this jetty has been cemented by shell-fish in the same manner as on the south jetty.

The crest of the exposed portions of this jetty can not be held at or above the level of mean low water without heavy capping. The portion capped with concrete in 1888 is entirely covered with sand.

Up to date, 97,581 square yards of mattress, 72,073.9 cubic yards of riprap, 5,325.41 cubic yards of shell, and 337.8 cubic yards of concrete have been used in the construction of this jetty.

CHANGES SHOWN BY SURVEY OF 1890.

Since the construction of the shore extension of the south jetty the shore in its vicinity, which had been receding, has begun to build out. The change is most marked to the south of the jetty.

The shore line at the inner end of the north jetty has advanced seaward, and the shore-work and sand-catches are nearly buried by the sand.

There has been but little change in the areas outside the jetties, to the north and south.

Between the jetties the action has been very marked. The north channel 18, 12, and 6 foot contours (on inside of bar) have pushed seaward 250, 1,150, and 2,150 feet respectively. The outer 6-foot contour of the bar has moved out an average of about 800 feet, while opposite the prolongation of the jetties there has been practically no movement of the outer 12 and 18 foot contours of the bar. Ward's bank has been lowered, narrowed, and pushed to the south and out, the sand carried out from it being mainly deposited on the outer slope of the bar to the south of the south jetty prolongation. All of this favorable action, however, has been necessarily accompanied by the narrowing of the south jetty channel by a decrease of depth on the crossing of the jetty middle ground, west of Ward's bank, and by a slight decrease of depth on the crossing of the outer bar.

WORK REQUIRED TO COMPLETE PROJECT.

It is not yet possible to state exactly how much work will be required on the jetties to complete the improvement at the mouth of the river. This will depend partly upon the physical conditions, including the amount of rainfall and the frequency, violence and direction of storms, and partly upon the manner in which the work is conducted, which in turn is dependent on the amount of funds available. It is now believed that the following work will be required, viz.:

North jetty.—Extend foundation to Station 11250, extend superstructure with crest at mean low water to Station 10000, build jetty to full height to Station 6700.

South jetty.—Extend foundation to Station 8500, extend mean low-water superstructure to Station 7100 and build jetty to full height to Station 4400.

The estimated cost of this work at the rates of the last contract is $465,000. The estimated cost of the improvement of the Dame's Point reach is $175,000. The total estimated cost of completing the improvement from Jacksonville to the ocean is thus $640,000 an improvement of $165,000 over General Gillmore's original estimate of the cost of the work. Of this increase $55,000 is in the Dame's Point estimate.

If the appropriations are made in the future as in the past irregularly and in insufficient amounts, the cost of the improvement may be correspondingly increased.

The changes produced by the work during the past year have been entirely satisfactory though it is unfortunate that the exhaustion of the sum allotted for jetty construction should have compelled the work to stop at such a critical time, when the south channel is almost closed and the north channel not yet opened. A sufficient sum has, however, been reserved to meet any emergencies which may arise before a new appropriation becomes available so as to prevent any interruptions to commerce.

This improvement is of vital importance to the city of Jacksonville

and to the other communities covering a large portion of the peninsula of Florida, for which the St. John's River is the natural marine highway. The importance of the St. John's as a gateway to the ocean arises not only from its position and navigable length, but also from the fact that almost every city of the peninsula can ship freight to some one of its ports over two or more competing railway lines. The amount of its prospective commerce, always large, has been enormously increased by the recent discovery of the extensive phosphate deposits of the State, the products of which have already begun to seek a market. This is a very bulky freight, and for economical reasons it must be shipped in bottoms deeper than can enter the St. John's River in its present condition. Its shipment through other ports is therefore attended by an increase of freight rates which must be paid by the farming communities of the entire country. This is also the case, though to a smaller degree with regard to the lumber, ship-stores, fruit and other products of Florida, a very large proportion of which is now shipped at increased cost from other sea-ports, some of which originally had no greater natural facilities than those afforded by the St. John's River. This diversion of traffic again militates against the St. John's River by diminishing the figures of the commercial statistics of the St. John's River called for by Congress annually for its guidance in making appropriations.

But the needs of the St. John's River are great not only from a commercial stand-point. The United States has begun a great engineering work which is now nearing completion. The work has been successful so far to a gratifying degree, and already has afforded substantial aid to commerce. It is now at a critical stage where, from past experience, it is believed but little more work is required to open a permanent channel, but where, if neglected, great harm can be done by a temporary, but complete, stoppage of navigation. Following natural laws, the ebb currents cling close to the jetties on either side. Where the jetties end the greater portion of the flow escapes across the jetties, and across their lines prolonged. No useful work is accomplished. The ultimate cost is greatly increased by deepening the water in which the jetties are to stand. The eroded sand is deposited on the bar, again increasing the cost by increasing the ultimate length of the jetties, and, what may be even worse, by decreasing the slope of the water surface over the reach affected by the jetties, diminishing the ebb velocities which form the tool used in clearing the channel.

Again the useful effect of the littoral currents and of the wave action of the northeast storms, on which the ultimate movement and deposit of the sand to the south of the jetties depend, is felt only on the outer slope of the bar and in comparatively deep water.

Could a deep channel be opened to the sea for the ebb currents, their load of sand would be deposited where it could be removed by storm waves and currents. With small appropriations such is not the case. The jetties can not catch up with the bar crest. The ebb currents cease to be confined inside the crest and the eroded sand is deposited within and on the crest which again is pushed seaward, and the ultimate success of the work is to that extent imperilled.

Again, as has been so often stated, the cost of the materials of construction themselves, is markedly greater in a small than in a large appropriation and the progress possible than much less.

For all of these reasons I would earnestly recommend that liberal appropriations be made for the remainder of this work.

In conclusion, I would desire to express my indebtedness to Lieut. D.

D. Gaillard, Corps of Engineers, Messrs. J. H. Bacon, assistant engineer, F. W. Bruce, superintendent, and W. T. McNelty, and J. S. Houston, inspectors, for faithful and interested work.

This improvement is located in the collection district of St. John's. Jacksonville is the nearest port of entry. Nearest light-house is St. John's River Light. Nearest fort is Fort Clinch, Fla.

The following papers accompany this report:

Report of J. H. Bacon, assistant engineer.
Dame's Point Survey:
Maps: Plates 2, 3, and 7, marked A, B, C.
Blue prints: Plates 1 (4 sheets), 4, 5, 6, and 8.
Annual survey, mouth of St. John's River, Fla:
Maps: Plates 1, 2, 3, and 4, marked D, E, F, G.

Money statement.

July 1, 1889, amount available		$41,259.08
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$18,164.57	
July 1, 1890, outstanding liabilities	1,159.76	
July 1, 1890, amount covered by uncompleted contracts made during fiscal year ending June 30, 1890	1,733.34	
		21,057.67
July 1, 1890, balance available		20,201.41
Amount appropriated by act of September 19, 1890		170,000.00
Amount available for fiscal year ending June 30, 1891		190,201.41
Amount (estimated) required for completion of existing project		470,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		470,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

Commerce of St. John's River, Florida, during the year ending December 31, 1889.

Articles.	Quantity.	Estimated value.	Gross tonnage.
Coal ..... tons	8,000	$56,000	8,000
Cedar logs ..... feet	300,000	105,000	5,400
Fertilizers ..... tons	27,358	687,950	27,358
Fruits ..... boxes	320,000	720,000	11,200
Grain, flour, etc ..... tons	38,901	972,225	38,901
Lumber (rough) ..... feet	9,201,795	92,170	36,840
Lumber (sawed) ..... B. M	135,795,795	2,606,310	543,180
Merchandise ..... tons	75,116	7,511,600	75,116
Passengers ..... number	12,000	300,000	.....
Total	.....	13,051,255	746,895

	No.	Aggregate tonnage.	Draft of water.
Coastwise:			
Steamers, 130 trips per year	5	230,000	11 feet in, 12 feet out.
Schooners, average 1½ trips a year	124	32,323	Average, 10 feet in.
West Indies:			
American schooners	15	3,780	Average, 12 feet out.
British sail	21	5,641	6 to 12 feet.
Total	.....	280,572	

This does not include the large number of yachts, steam and sail, no record being kept.

Increase of trade owing to improvement, 70 per cent.

Probable increase were the improvement completed, incalculable.

The above does not include all of the commerce that crosses the bar at the mouth of the St. John's River, as much is consigned to individual shippers and the volume of which is hard to obtain, no record, other than estimated, being kept. The amount above given is possibly not more than 60 per cent. of the trade.

The light tonnage to foreign ports is owing to the want of continual improvements, as many ships would engage in the lumber and growing phosphate trades were they able to enter the port of Jacksonville.

To further improve the St. John's River would insure a continuous increase in the volume of commerce, on which east, south, and middle Florida largely depends. The volume of commerce crossing the bar, owing to the improvements already made, necessitated the establishment of a line of fine sea-going steamers making two and a half trips a week, and further necessitating an increase in the number of these vessels.

HENRY MARCOTTE.

REPORT OF MR. J. H. BACON, ASSISTANT ENGINEER, ON SURVEY OF ST. JOHN'S RIVER, FLORIDA, FROM GREAT MARSH ISLAND TO TROUT CREEK.

UNITED STATES ENGINEER OFFICE,
St. Augustine, Fla., May 1, 1890.

CAPTAIN: I have the honor to submit the following report on the survey of St. John's River, Fla., from Great Marsh Island to Trout Creek.

The work consisted in:

1. Triangulation.
2. Soundings and locating shore-lines.
3. Determining velocity and direction of current at various points, and gauging the stream.
4. Boring to determine character of bottom.
5. Obtaining and analyzing samples of water.
6. Observing tidal phenomena.
7. A survey of Dame's Point Peninsula for a ship-canal.

The field work of the survey was begun on January 14, 1889, and was finished on May 4, 1889. The work was frequently delayed by windy and rainy weather.

The field party consisted of myself, Messrs. E. F. Smith, A. C. Harper, J. L. Brownlee, and Otto Bie.

I. TRIANGULATION.

That portion of the river between Great Marsh Island and Reddie's Point was carefully triangulated; signals were erected over each triangulation point; angles were repeated at each station, and were adjusted by systems of quadrilaterals. The base-line used was the line between two U. S. Coast Survey stations. This distance was checked at the lower end of the survey by a carefully measured check base.

II. SOUNDINGS AND LOCATING SHORE-LINES.

The river was sounded thoroughly from Great Marsh Island to Trout Creek. The soundings were made with a pole or lead-line, and were located by the ordinary method of two transits. The boat was kept on the proper course by signals from a man on shore, provided with a compass and flag. The soundings were reduced to mean low water by the following method: The approximate difference in elevation of the zeros of the gauges at Fulton, Dame's Point, and Chaseville were ascertained as will be described under the subhead "Tidal phenomena;" the gauges were plotted at proper intervals on cross-section paper and the mean low waters connected by straight lines. By referring to the tidal records the slope at any time during the day could be plotted. The difference between this line of slope and the line of mean low water, at the proper distance from a given gauge, gave the required correction at the corresponding point on the map.

III. CURRENT OBSERVATIONS.

In determining velocities two current meters were used, an Ellis meter, made by Buff & Berger, and a Price meter, with a slight modification, made by W. & L. E. Gurley. The first meter has been in use since 1879; the second was new and used for the first time by myself. The ordinary electric registering apparatus was used with the Price meter. The revolutions of the Ellis meter were recorded by a register de-

vised in your office and made by the Novelty Electric Company, of Philadelphia, Pa. In this register no spring motor is required, the motive power being given by the armature. The electric current in the register is made in the usual manner through an electric magnet, two Le Clanche cells being used. The armature of this magnet swings on a vertical axis and is provided with an adjusting spring. Its end produced carries a pallet engaging with a scrape-wheel, which moves a unit hand and in turn is connected with a train of wheels moving hands for registering tens, hundreds, and thousands, on curve spending circles.

In observing velocities with the current meters, the instrument was placed first at about 1 foot from the bottom and the register read; at the end of three minutes the register was again read and the meter raised 3 feet; this operation was repeated until the surface of the water was reached. The meter was again lowered to the bottom and a new set of observations taken. A balance-frame, to allow for the vertical motion of the boat, was used with each meter. The meters were rated twice during the progress of the work.

The direction of the currents at the bottom, mid-depth, and surface was noted by the observer by means of surface and subsurface floats, connected with fine cord. Whenever it was necessary to obtain the direction of the current the floats were dropped over the side of the boat and allowed to drift free for a distance of about 150 feet, and the direction noted. The floats were then hauled back to the boat by lines attached and the operation repeated.

The following apparatus was also used successfully in smooth water: A 5-foot length of 2-inch gas-pipe was fastened vertically to the stem of the boat; in each end of this was inserted a plug, with a hole five-eighths of an inch in diameter; an iron rod with a vane attached to the bottom was passed up through these holes and held at any desired depth by a collar and set-screw. A pointer attached to the collar indicated the direction of the current.

For gauging the stream two cross-sections were chosen, No. 1 at St. John's Bluff and No. 2 at Dame's Point. Cross-section No. 1 was subdivided into three sections and No. 2 into five sections. In taking the observations the observations extended through an entire tide, ebb or flood. Besides these stations velocities were observed at ten other stations at different points, making eighteen stations in all.

The observed mean velocity was obtained in the following manner: A mean of the velocities observed during the transit of the meter from the bottom to the surface was assumed to be the mean velocity of the vertical plane at the time that the mid-depth velocity was taken; the times of the mid-depth velocities were plotted on the axis of abscissas, and the corresponding means of the velocities in vertical plane were plotted on the axis of ordinates. The area included between this curve and the axis of abscissas was divided by the duration of the tide in seconds, and the result taken as the mean observed velocity for the entire tide.

The maximum value of y was assumed to be the maximum observed velocity. The means of the velocities observed at the bottom, mid-depth, and surface was taken as the mean observed velocities at those points.

At most of the stations in each of the gauging sections, two flood and two ebb tides were observed. The observed mean velocities for flood or ebb at the same station were found to differ greatly (plate No. 7) and in each case seemed to vary as some function of "H" or the maximum difference of the level between water-suraces at Fulton and Dame's Point. As these two gauges are 5 miles apart it is evident that at the time of this maximum difference the velocity of the current at either point would not be at the maximum. But lacking better date, it was assumed that the mean velocity would vary as the equation

$$(1) \quad v = k\sqrt{rh}$$

Where k is an unknown constant, r the hydraulic radius, and h the maximum difference of level of water-surfaces during the tide under consideration. Of these quantities v, r, and h were known by observation. It is evident that if the equation is true, considering two ebb tides at the same station, equal values of k would be obtained; the same would be true of two flood tides at the same station. A value for k was obtained for each observed tide, and substituted in the equation

$$(2) \quad V = k\sqrt{RH}$$

where V is the desired mean velocity, R the mean hydraulic radius, and H the mean maximum difference in level of the water-surfaces.

The differences between the corresponding observed velocities vary from 0.10 foot per second to 0.52 foot per second; the differences between corresponding values of V obtained by the formula vary from 0.04 foot per second to 0.08 foot per second.

These differences can probably be accounted for by the effect of wind, for which no allowance was made in the formula.

The observations were made under normal conditions, as nearly as possible.

In calculating the discharge, the mean velocity for each section in the cross-section was calculated from the mean velocity at the station (Plate 4.) This velocity multiplied by the area of the section in square feet, multiplied by the duration of the tide in seconds, gave the required discharge.

It is evident that a mean discharge for a river like the St. John's can not be obtained except from observations extending through a great length of time. The difference in duration of the tides alone is sufficient to prevent this. Several times during the survey the tide was observed to run out, on the surface at least, during the entire rise; on other occasions it ran in during the entire fall. This was due to the force and direction of the wind. The mean discharge given in the table (Plate 7) is probably very nearly correct under normal conditions.

The directions of the current (Plate 3) are nearly constant, changing only between the end and beginning of a tide.

As shown by the path of the floats, most of the water passing Dame's Point during the ebb and most of the water passing Mill Cove Point during flood escapes through the Mill Cove Channel, while the velocities in the Dame's Point channels are greater than those in the Mill Cove Channel.

At Station No. 1, at St. John's Bluff, flood begins at the bottom about thirty minutes before it begins at the surface, and continues about forty-five minutes after it begins to ebb at the surface. This was not noticed at Dame's Point, where there was frequently no slackwater between the tides, the current gradually changing from ebb to flow, and *vice versa*.

An attempt was made to deduce from the report of General Gillmore (Report of Chief of Engineers, 1870, Appendix I 7, part 1, page 767) a discharge at Mayport corresponding to a mean low water of 0.60 and a range of 4.15, the means of the observations taken at Mayport during the progress of this survey. The result obtained is evidently too small (Plate 7). In making this deduction the mean velocities and durations obtained by General Gillmore were used.

The values given in plate 7 are relatively correct, and very nearly so for normal conditions.

IV. BORINGS.

Borings were made by means of a water jet through gas-pipe. The pump used was a Gould double-acting suction and force pump, with a 1½-inch suction and a 1-inch discharge worked by two men, and capable of discharging about 50 gallons per minute.

In making the borings, 2-inch gas-pipe was forced down from 5 to 10 feet through the bottom; 1-inch pipe was then inserted in the large pipe and forced down to the required depth. As the smaller pipe went down samples of the bottom were brought to the surface through the space between the pipes. Plate No. 8 shows the depth and character of the borings. One hundred and twenty-seven samples of bottom were preserved and are submitted with this report.

V. OBSERVATIONS FOR DENSITY AND SEDIMENT.

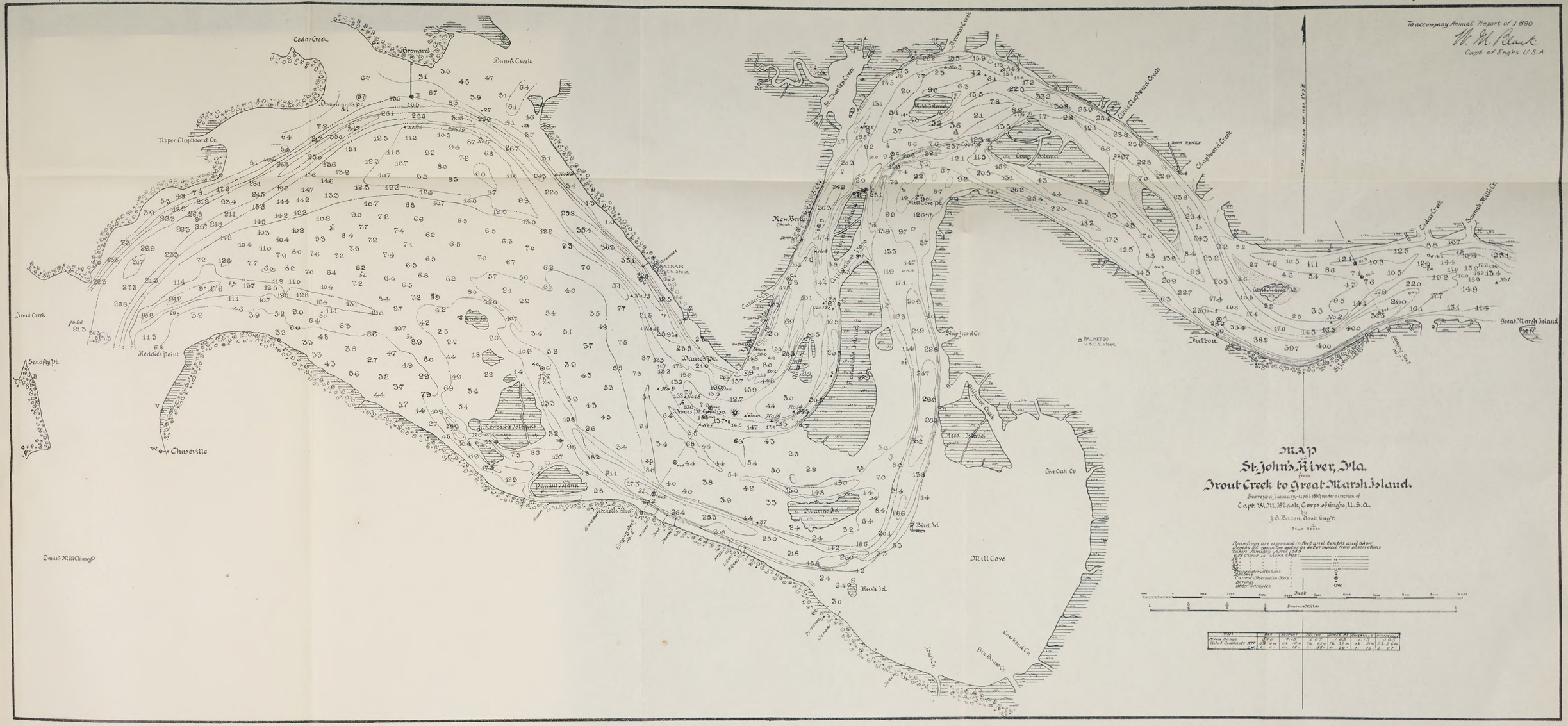
Water samples at various depths were obtained by an apparatus designed by Lieut. D. D. Gaillard, Corps of Engineers. It consists of two iron plates 1 foot square and one-fourth of an inch thick, held together by four iron pipes, leaving a space of 1 inch between the plates. An iron pipe 1 foot in length, through which the anchor line is passed, is fastened through the center of the plates. Hose connected with a pump is coupled to a nipple passing through the upper plate. The plates are run up and down the anchor line, which is kept as nearly vertical as possible. A sample of water can be obtained at any required depth, as only the water passing between the plates is brought to the surface. The anchor used with the apparatus was a thin plate of cast-iron weighing about 100 pounds. The anchor line was made fast by passing it through a hole in the center of the plate and knotting it on the under side. This allowed the plates to rest evenly on the anchor while obtaining a sample at the bottom. Three ordinary anchors were used to hold the boat in position.

The water samples were analyzed as follows:

The weight of one cubic foot of water was first obtained by the salinometer. The water was then carefully filtered through fine filtering paper. Two papers had been previously cut and made of exactly the same weight, one used for filtering and the other laid aside. The filter paper containing the sediment was thoroughly dried and placed in one pan of the balance, and the duplicate in the other. The weight necessary to make the scales balance was taken as the weight of the sediment. The results obtained are tabulated in plate No. 8. Sixty-three samples in all were taken, but twenty-one were lost in transportation

Survey of St. John's River, Fla., at Dame's Point. 1889.

Plate No. 2.A



To accompany Annual Report of 1890

W. M. Black

Capt. of Engrs U.S.A.

Map of St. John's River, Fla. from Trout Creek to Great Marsh Island.

Surveyed, January-April 1889, under direction of Capt. W. M. Black, Corps of Engrs, U.S.A. by J. D. Bacon, Asst. Engr.

Scale 1:20000

Soundings are expressed in feet and tenths and show depths at mean low water as determined from observations taken January-April 1889

Curve of Mean Tides

Temperature Stations

Current Observation Stations

Drifting Water Samples

Nautical Miles

Kind	Rise	Interval	Flood	Ebb	Duration
Mean Range	6.0 ft.	6h 13m	12h 26m	6h 13m	12h 26m
Spring Range	6.8 ft.	6h 13m	12h 32m	6h 13m	12h 26m
Neap Range	4.6 ft.	6h 13m	12h 20m	6h 13m	12h 26m

Photo-Lith. by A. HOEN & CO., Balto., Md.

Survey of St. John's River, Fla., at Dame's Point: 1889.

Plate No. 3. B

To accompany Annual Report of 1890

W. M. Black

Capt. of Engrs U.S.A.



MAP
of
St. John's River, Fla.
from
Trout Creek to Great Marsh Island.

Showing location of Current-observation Stations, Borings, Water-Samples &c. (Surveyed Jan/May 1889)

6 ft. Curve is shown thus: ———— . ————

12- " " " " ———— .. ————

18- " " " " ———— ... ————

Current-observation Stations are shown thus: ◎

Borings " " " ●

Water Samples " " " ○

Direction of current is " " ————→

Velocity of current is represented by the length of the arrow; the figures show mean velocity, in feet per second. Scale: 0 1 2

Path of Flood Floats is shown thus: ~~~~ - - - - - - →

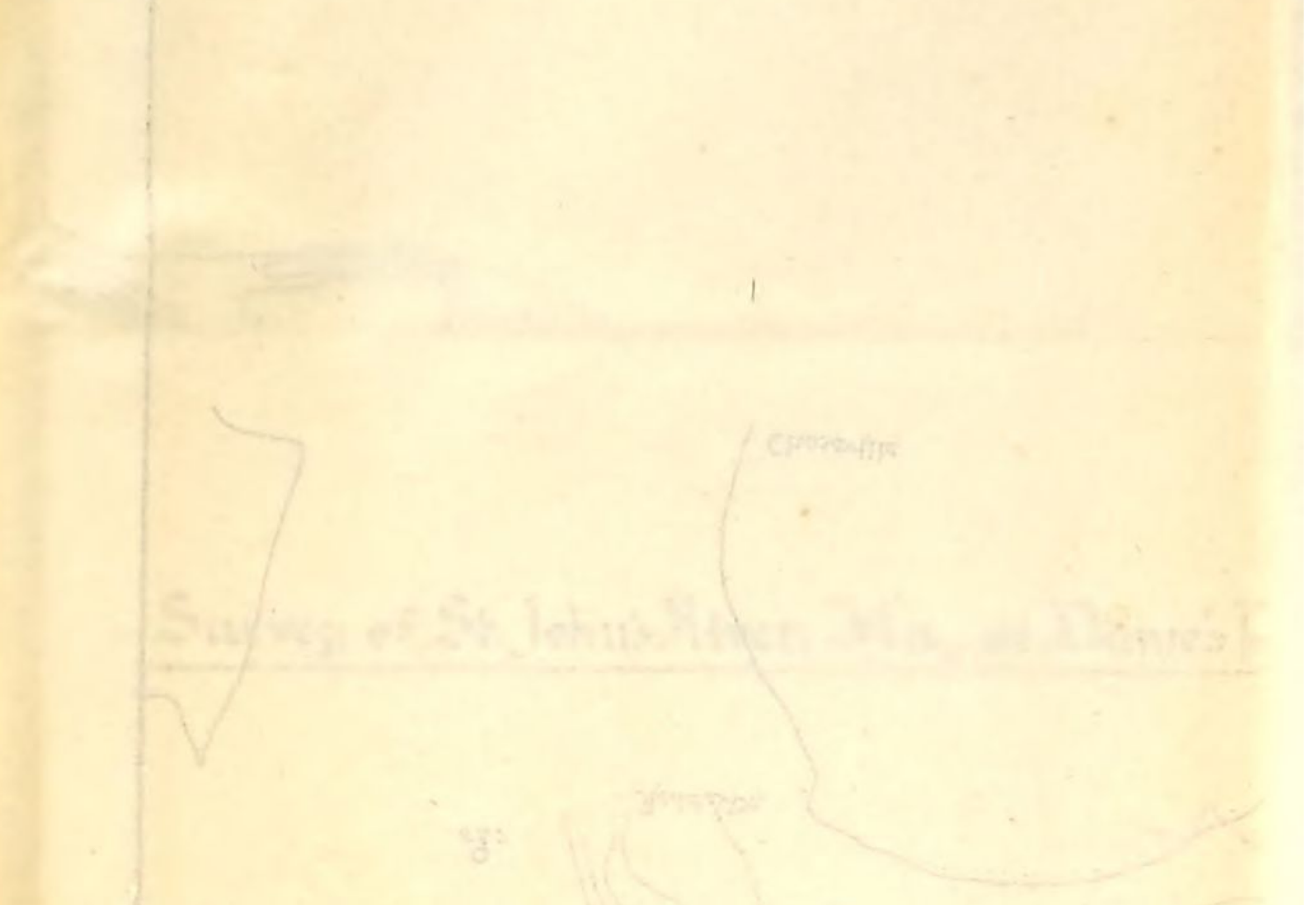
" " Ebb " " " ~~~~ ———— →

These floats were started at the beginning of the tide, and were allowed to float free until nearly Slack Water. They consisted of rods, submerged 5 ft. below the water surface, and weighted so as to float in a vertical position.

Scale

1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 ft.

Photo-Lith. by A. HOEN & CO., Baltn., Md.



SURVEY OF ST. JOHN'S RIVER, FLORIDA, AT DAME'S POINT, 1889.

[Plate No. 7, C.]

[Explanation.—Vm, Vm = Mean velocity of vertical plane for entire tide, in feet per second; $Vmax$, $Vmax$ = Maximum mean velocity of vertical plane for entire tide, in feet per second; Vb, Vb = Mean bottom velocity for entire tide, in feet per second; $V\frac{1}{2}$, $V\frac{1}{2}$ = Mean mid-depth of velocity for entire tide, in feet per second; Vs, Vs = Mean surface velocity for entire tide, in feet per second; $Hmax$ = Maximum difference of level between water surfaces at Dame's Point and Fulton; R = Hydraulic radius at mean stage; P = Wetted perimeter at mean stage; M = Mayport; F = Fulton; D. P. = Dame's point. Mean stage is that height at which the water surface would remain fixed if there were no rise or fall of the tide during flood or ebb.]

OBSERVED VALUES.

	Cross-section.	Station.	Date, 1889.	Observed velocities. Vm	$Vmax$	Vb	$V\frac{1}{2}$	Vs	Observed ratios. $\frac{Vm}{Vmax}$	$\frac{Vm}{Vb}$	$\frac{Vm}{V\frac{1}{2}}$	$\frac{Vm}{Vs}$	$Hmax$	R.	Duration, seconds.	Range. M.	F.	D.P.	Height at which tide— Began.	Ceased.	Mean stage.
													Feet.	Feet.		′	′	′	′		
	1	1	Apr. 5	1.20	1.70	0.91	1.69	1.11	.706	1.318	.710	1.081	0.27	24.8	14,400	3.30	2.65	1.61	3.08	3.61	3.65
	1	1	Apr. 8	0.90	1.43	0.82	1.26	1.05	.630	1.097	.714	.857	0.30	24.6	16,200	2.25	3.82	1.37	3.10	3.30	3.49
	1	2	Apr. 6	0.76	0.96	0.47	0.77	1.08	.791	1.617	.987	.704	0.28	10.5	12,960	3.40	2.60	1.60	3.27	3.45	3.56
	1	3	Apr. 22	0.90	1.27	0.56	1.00	1.18	.708	1.607	.900	.763	0.23	10.6	17,400	3.90	2.58	1.56	2.25	3.60	3.33
	2	1	Mar. 7	0.86	1.39	0.64	1.05	1.47	.620	1.344	.819	.585	0.19	15.0	11,700	3.60	2.02	1.25	3.55	3.75	3.78
	2	1	Apr. 4	1.65	1.29	0.96	1.17	1.34	.814	1.094	.897	.783	0.28	14.4	12,600	3.70	2.59	1.65	3.10	2.88	3.23
	2	2	Mar. 7	0.39	0.60	0.20	0.53	0.73	.650	1.950	.755	.534	0.19	8.3	10,800	3.60	2.02	1.25	3.55	3.80	3.79
	2	2	Apr. 4	0.52	0.76	0.43	0.59	0.65	.684	1.210	.881	.800	0.28	7.7	12,600	3.70	2.59	1.65	3.29	2.75	3.23
	2	3	Mar. 5	1.16	1.54	0.87	1.05	1.36	.753	1.333	1.105	.853	0.37	14.5	13,800	4.40	2.56	1.49	3.95	3.83	4.09
	2	3	Apr. 3	0.64	1.03	0.53	0.74	0.80	.621	1.207	.865	.800	0.33	13.8	12,600	4.25	2.69	1.66	3.12	3.10	3.35
	2	4	Apr. 2	0.60	0.90	0.41	0.62	0.84	.666	1.463	.967	.714	0.32	6.1	16,200	4.70	3.08	1.70	2.95	3.10	3.35
	2	5	Apr. 3	0.60	0.93	0.40	0.72	0.85	.645	1.500	.833	.713	0.33	16.5	13,800	4.25	2.69	1.66	3.35	2.60	3.28
Flood	2	5	Apr. 2	0.93	1.34	0.69	1.08	1.43	.694	1.350	.821	.650	0.52	16.5	17,760	4.70	3.08	1.70	3.10	2.78	3.30
														Depth.							
		A	Apr. 22	1.20	1.88	0.96	1.31	1.79	.640	1.250	.916	.670	0.23	27.3	15,560	3.90	2.58	1.56	3.00	3.20	
		C	Apr. 20	0.98	1.32	0.85	1.10	1.52	.742	1.153	.891	.645	0.37	15.0	14,700	5.00	2.87	1.78	3.42	3.62	
		C^1	Apr. 20	0.58	0.91	0.34	0.66	0.74	.637	1.706	.876	.784	0.37	9.8	14,700	5.00	2.87	1.78	3.34	3.80	
		C^2	Mar. 4	1.41	1.88	1.27	1.55	1.72	.750	1.110	.910	.820	0.46	16.7	18,000	4.50	2.73	1.60	3.50	4.20	
		C^3	Mar. 4	0.97	1.33	0.80	1.10	1.20	.730	1.090	.882	.808	0.46	15.2	18,000	4.50	2.73	1.60	3.50	4.20	
		G	May 2	0.83	1.25	0.58	1.00	1.27	.664	1.431	.830	.654	0.33	37.0	14,700						
		G^1	May 2	0.65	0.91	0.45	0.69	0.94	.714	1.444	.942	.691	0.33	11.8	14,700						
		H^1	Apr. 23	1.63	2.17	1.11	1.86	2.17	.751	1.468	.876	.751	0.42	25.2	20,400			1.78	3.30	3.30	
		H	Apr. 23	0.94	1.23	0.54	1.03	1.29	.764	1.741	.913	.953	0.42	19.8	20,400			1.78	3.30	3.30	
	1	1	Apr. 16	2.23	3.74	1.68	2.57	3.49	.596	1.327	.867	.639	0.90	23.6	26,400	5.20	3.04	1.87	3.90	3.10	2.50
	1	1	Apr. 17	2.39	3.52	2.03	2.96	3.40	.678	1.177	.807	.703	0.98	23.5	25,500	5.05	3.09	1.83	4.00	2.60	2.39
	1	2	Apr. 26	1.20	1.75	1.03	1.20	.....	.685	.....	1.000	.....	0.98	.....	22,440	.....	3.09	1.83	.....	.....	.....
	1	3	Apr. 17	1.07	0.96	0.83	0.86	1.50	.812	1.208	.930	.553	0.98	9.4	23,580	5.05	3.09	1.83	4.00	2.60	2.39
	2	1	Apr. 11	1.53	2.26	1.11	1.65	2.12	.672	1.370	.921	.717	0.65	14.1	26,100	3.45	2.48	1.59	3.50	3.50	2.94
	2	1	Apr. 12	1.74	2.26	1.27	1.92	2.21	.770	1.370	.906	.787	0.91	14.0	28,200	4.05	2.70	1.74	3.39	3.37	2.83
	2	2	Apr. 11	1.16	1.73	0.96	1.21	1.38	.670	1.208	.959	.840	0.65	7.4	26,100	3.45	2.48	1.59	3.50	3.50	2.94
	2	2	Apr. 12	1.26	1.71	1.03	1.35	1.48	.736	1.223	.977	.851	0.91	7.3	27,000	4.05	2.70	1.74	3.39	3.28	2.83
	2	3	Feb. 28	1.23	1.73	1.09	1.36	1.47	.711	1.128	.904	.836	0.95	13.5	26,040	4.95	3.02	1.79	3.82	3.45	3.15
	2	3	Apr. 13	1.03	1.33	0.82	1.07	1.17	.774	1.255	.962	.880	0.93	13.0	27,000	.....	3.50	1.80	3.67	3.15	2.57
	2	4	Apr. 1	0.67	0.92	0.65	0.69	0.74	.728	1.032	.971	.905	0.89	5.5	22,800	4.90	3.14	1.79	2.70	3.00	2.47
Ebb	2	5	Apr. 1	1.24	1.67	0.96	1.43	1.65	.748	1.291	.867	.751	0.89	.....	25,800	4.90	3.14	1.79	2.95	.....	.....
														Depth.							
		A	Apr. 26	1.51	2.12	1.09	1.83	2.17	.712	1.385	.825	.696	0.90	27.3	26,500	.....	.....	.....	.....	.....	.....
		C	Apr. 15	1.62	2.17	1.25	1.75	2.06	.747	1.296	.926	.786	0.97	15.0	23,160	4.90	3.20	1.99	.....	.....	.....
		C^1	Apr. 15	1.20	1.67	0.94	1.29	1.25	.749	1.330	1.042	1.000	0.97	9.8	23,160	4.90	3.20	1.99	.....	.....	.....
		C^2	Feb. 27	1.90	2.42	1.61	2.12	2.17	.785	1.180	.896	.876	0.97	16.7	26,100	4.75	.....	1.62	4.08	3.45	.....
		C^3	Feb. 27	1.49	2.11	1.14	1.58	1.85	.705	1.308	.943	.805	0.97	13.2	26,100	4.75	.....	1.62	3.90	3.50	.....
		G	Apr. 24	1.50	2.28	1.11	1.74	1.92	.658	1.351	.862	.781	0.98	37.0	26,100	.....	.....	1.75	3.15	3.50	.....
		G^1	Apr. 24	0.92	1.23	0.71	0.93	1.07	.748	1.295	.988	.860	0.98	11.8	21,600	.....	.....	1.75	2.90	2.95	.....
		H^1	Apr. 25	1.27	1.88	1.05	1.36	1.68	.676	1.210	.934	.756	0.95	25.2	27,300	.....	.....	1.65	3.10	3.78	.....
		H	Apr. 25	0.86	1.16	0.56	0.96	1.54	.741	1.536	.896	.754	0.95	19.8	27,300	.....	.....	1.65	2.15	3.80	.....

OBSERVED VALUES REDUCED TO CORRESPONDING VALUES FOR A TYPICAL TIDE.

Cross-section.	Station.	Mean velocities and ratios at stations. Vm	$Vmax$	Vb	$V\frac{1}{2}$	Vs	$\frac{Vm}{Vmax}$	$\frac{Vm}{Vb}$	$\frac{Vm}{V\frac{1}{2}}$	$\frac{Vm}{Vs}$	Mean velocities in sections. Vm	$Vmax$	Vb	$V\frac{1}{2}$	Vs	$Hmax$	R	P	Area.	Duration, seconds.	M. H. W.	M. L. W.	M. range.	Height at which tide— Began.	Ceased.	Mean stage.	Mean discharge.
																Feet.	Feet.	Feet.	Sq. feet.								Cubic feet.
1	1	1.04	1.56	0.86	1.46	1.07	.668	1.207	.712	.969	0.98	1.48	0.81	1.38	1.01	.....	25.1	1,164	29,220	.....	.....	.....	.....	.....	.....	.....	436,406,000
1	2	0.84	1.06	0.52	0.85	1.19	.791	1.617	.987	.704	0.90	1.14	0.56	0.91	1.28	.....	11.0	991	10,907	.....	.....	.....	.....	.....	.....	.....	149,600,000
1	3	1.12	1.58	0.70	1.24	1.47	.708	1.607	.900	.763	0.95	1.34	0.58	1.05	1.24	.....	11.3	827	9,443	.....	.....	.....	.....	.....	.....	.....	136,718,000
Totals		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.33	16.6	2,982	49,570	15,240	4.34	1.67	2.67	3.41	3.91	4.00	722,724,000
1	1	1.13	1.58	0.93	1.32	1.65	.717	1.219	.858	.686	0.96	1.34	0.79	1.12	1.40	.....	14.8	1,524	22,643	.....	.....	.....	.....	.....	.....	.....	294,323,000
2	1	0.54	0.81	0.34	0.66	0.67	.667	1.580	.818	.800	0.59	0.88	0.37	0.72	0.74	.....	8.1	250	2,020	.....	.....	.....	.....	.....	.....	.....	16,137,000
3	1	0.86	1.25	0.67	0.87	1.04	.687	1.270	.985	.826	0.79	1.15	0.62	0.89	0.96	.....	14.0	664	9,304	.....	.....	.....	.....	.....	.....	.....	99,521,000
4	2	0.47	0.70	0.32	0.48	0.66	.666	1.463	.967	.714	0.62	0.93	0.42	0.64	0.87	.....	6.3	2,420	15,225	.....	.....	.....	.....	.....	.....	.....	127,811,000
5	2	0.66	0.99	0.46	0.80	0.95	.669	1.425	.827	.692	0.58	0.87	0.47	0.70	0.84	.....	16.8	1,052	17,611	.....	.....	.....	.....	.....	.....	.....	138,303,000
Totals		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1	A	1.42	2.22	1.14	1.55	2.12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	C	0.92	1.24	0.80	1.03	1.43	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	C^1	0.54	0.84	0.32	0.62	0.69	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	C^2	1.19	1.57	1.07	1.31	1.45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	C^3	0.81	1.11	0.74	0.92	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	G	0.83	1.25	0.58	1.00	1.27	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	G^1	0.65	0.91	0.45	0.69	0.94	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	H^1	1.43	1.90	0.91	1.63	1.90	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	H	0.82	1.07	0.47	0.90	0.86	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1	1	2.24	3.52	1.78	2.67	1.85	.637	1.258	.837	.671	2.00	3.14	1.59	2.29	2.98	.....	23.7	1,163	27,575	.....	.....	.....	.....	.....	.....	.....	1,433,900,000
2	1	1.18	1.72	0.99	1.18	1.47	.685	1.189	1.00	.800	1.35	1.97	1.13	1.35	1.69	.....	9.6	991	9,555	.....	.....	.....	.....	.....	.....	.....	335,374,000
3	1	1.05	1.29	0.87	1.12	1.97	.812	1.208	.930	.533	0.98	1.29	0.81	1.05	1.84	.....	10.0	826	8,297	.....	.....	.....	.....	.....	.....	.....	211,406,000
Totals		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.90	15.3	2,980	45,427	26,000	4.34	1.67	2.67	3.82	3.32	2.62	1,980,680,000
1	1	1.73	2.40	1.26	1.89	2.30	.721	1.370	.913	.752	1.52	2.11	1.11	1.66	2.02	.....	13.9	1,523	21,305	.....	.....	.....	.....	.....	.....	.....	851,689,000
2	1	1.30	1.85	1.03	1.37	1.37	.703	1.215	.948	.945	1.30	1.89	1.07	1.37	1.38	.....	7.2	250	1,800	.....	.....	.....	.....	.....	.....	.....	61,542,000
3	1	1.10	1.48	0.92	1.17	1.28	.742	1.192	.936	.858	1.08	1.47	0.91	1.15	1.26	.....	13.1	664	8,720	.....	.....	.....	.....	.....	.....	.....	247,667,000
4	1	0.68	.934	0.66	0.70	0.75	.728	1.031	.971	.905	0.85	1.17	0.82	0.87	0.94	.....	5.7	2,420	13,978	.....	.....	.....	.....	.....	.....	.....	312,478,000
5	2	1.26	1.68	0.97	1.45	1.44	.750	1.287	.870	.890	1.13	1.51	0.87	1.29	1.27	.....	16.2	1,026	16,762	.....	.....	.....	.....	.....	.....	.....	496,367,000
Totals		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1	A	1.44	2.02	1.04	1.74	2.07	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	C	1.57	2.10	1.21	1.69	2.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	C^1	1.20	1.60	0.90	1.15	1.20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	C^2	1.84	2.34	1.56	2.05	2.10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	C^3	1.44	2.04	1.10	1.53	1.79	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	G	1.44	2.19	1.07	1.68	1.84	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	G^1	0.88	1.17	0.68	0.88	1.02	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	H^1	1.24	1.83	1.02	1.33	1.64	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	H	0.93	1.25	0.60	1.03	1.23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

COMPARISON OF CROSS-SECTIONS.

	Mayport. Flood.	Mayport. Ebb.	St. John's Bluff (No. 1). Flood.	St. John's Bluff (No. 1). Ebb.	Dame's Point (No. 2). Flood.	Dame's Point (No. 2). Ebb.
Mean H. W., January–May, 1889	4.75′		4.34′		3.84′	
Mean L. W., January–May, 1889	0.60′		1.67′		2.21′	
Mean range, January–May, 1889	4.15′		2.67′		1.63′	
Tidal constants, January–May, 1889, H. W	0.0		55 minutes.		1 hour 22 minutes.	
Tidal constants, January–May, 1889, L. W	0.0		48 minutes.		1 hour 19 minutes.	
Difference of level of M. L. W. planes (approximated)	0.0		1.07′		1.61′	
Width of water surface at cross-section	*1, 914′	1, 804′	2, 971′	2, 969′	5, 895′	5, 869′
Wetted perimeter at cross-section			2, 982′	2, 980′	5, 910′	5, 883′
Hydraulic radius at cross-section			16.6′	15.3′	11.3′	10.6′
Area at cross-section	*40, 419′	36, 354′	49, 571′	45, 428′	66, 802′	62, 589′
Mean velocity at cross-section	*1.63′	†2.19				
Duration of flow (seconds)	*18, 000′	24, 300	15, 240	26, 000	15, 540	26, 300
Discharge (cubic feet)	*[1, 188, 828, 000	†1, 934, 651, 000	722, 724, 000	1, 980, 680, 000	676, 095, 000	1, 969, 743, 000
Amount of fresh water passing through section	*1745, 823, 000		1, 257, 956, 000		1, 293, 648, 090	
Ratio of fresh water to ebb discharge	*1.385		.635		.657	
Ratio of flood discharge to ebb discharge	*1.620		.365		.339	
Ratio of flood (No. 2) discharge to flood discharge (No. 1)					.935	
Ratio of ebb (No. 2) discharge to ebb discharge (No. 1)					.994	
Mean height at which flow begins	*2.80′	3.15′	3.41′	3.82′	3.37′	3.17′
Mean height at which flow ceases	*3.85′	2.60′	3.91′	3.32′	3.31′	3.23′
Mean rise of tide before flood begins	*2.20′		1.74′		1.16′	
Mean fall of tide before flood ceases	*0.90′		0.43′		0.53′	
Mean fall of tide before ebb begins	*1.60′		0.52′		0.67′	
Mean fall of tide before ebb ceases	*2.00′		1.65′		1.02′	
Mean stage	*4.04′	1.79′	4.09′	2.62′	3.59′	2.71′

Observed mean stage for flood = $\frac{1}{2}$[H. W. + $\frac{1}{2}$ (height at which tide began + height at which tide ceased)].
Observed mean stage for ebb = $\frac{1}{2}$[L. W. + $\frac{1}{2}$ (height at which tide began + height at which tide ceased)].
All tidal elevations refer to the zero of the Mayport gauge (approx.).

*Calculated for a M. L. W. of 0.60′ and a mean range of 4.15′, from report of General Q. A. Gillmore. (See Report of Chief of Engineers, U. S. A., 1879 Appendix I 7, Part 1, page 767.)
†Doubtful.

VI. TIDAL PHENOMENA.

The rise and fall of the tides were observed daily at Mayport and Dame's Point. Tidal observations were also made for a short period at Chaseville and Jacksonville. The readings of the gauges were noted and recorded every 15 minutes.

The zeros of the gauges at Fulton and Dame's Point were set at the same level by the following method:

Seven gauges were set at random at equal intervals between Fulton and Dame's Point, and observed simultaneously every five minutes during two successive slack-waters. The mean of differences between the simultaneous readings during low-water slack, taking the gauges in pairs (1 and 2, 2 and 3, etc.,) was added to the corresponding mean of differences during high-water slack, and the sum divided by 2. This last result was taken as the difference in elevation of the zeros of the two gauges.

These means are tabulated as follows:

	Gauges.					
	1 and 2.	2 and 3.	3 and 4.	4 and 5.	5 and 6.	6 and 7.
Mean of differences at high-water slack	0.36	0.38	3 63	4.13	0.23	0.34
Mean of differences at low-water slack	0.23	0.45	3.57	4.14	0.35	0.40
Total	0.59	0.83	7.20	8.27	0.58	0.74
Differences in elevation of zeros	0.29	0.42	3.60	4.13	0.27	0.37

The gauges were then placed at the same level. This work has been tested by comparing slackwater readings of the gauges at Dame's Point and Fulton for a num- of days. The result showed a difference in elevation of 0.01. The actual difference in elevation, if any, of the zeros of these two gauges is not greater than 0.05. The difference in elevation between Mayport and Fulton zeros, and between those at Dame's Point and Chaseville, and Chaseville and Jacksonville, were found by the same method. These results, however, are only approximate.

An attempt was made to discover some relation between the tidal ranges at the different points on the river, but no law could be deduced.

In a general way, however, an increase of range at Mayport gives rise to an increased range at all points on the river. The tides are greatly affected by the winds; the same wind that tends to heap up the water in one place sometimes lowers it in another.

It is noticeable that the mean low water at Mayport is 0.60 higher than that obtained in 1879; and comparison with earlier maps shows either that the river has deepened between the limits of the survey or that the plane of mean low water has risen.

VII. CANAL ACROSS DAME'S POINT PENINSULA.

A survey of the peninsula was made for the purpose of locating a ship-canal (plate No. 5). Stadia measurements were used for determining distances, and contour lines, 5 feet apart in height, were established by accurate leveling. The first and last stations of the stadia line were connected with the main triangulation system of the river, and the distance between them checked. The few borings taken show the material to consist of sand and mud.

For more complete information of the results of this survey, I would respectfully refer you to the following plates which are submitted with this report:

List of plates.

No.	Description.	Scale.	Number of copies.
1	Complete map	$\frac{1}{5000}$	1 map (3 sheets); 1 tracing (4 sheets).
2	Complete map	$\frac{1}{20000}$	1 map, 2 tracings.
3	Map showing velocities, borings, water samples, etc	$\frac{1}{20000}$	2 tracings.
4	Diagram of cross-sections, and velocities	....	1 tracing.
5	Map showing location and profile of ship-channel	$\frac{1}{5000}$	1 tracing.
6	Table of distances, azimuths, bench-marks, tidal notes, etc	.....	1 tracing.
7	Table of velocities	.....	1 tracing.
8	Table of borings and water samples	.....	1 tracing.
9	Velocity curves	.....	19 sheets (no tracings).

Very respectfully, your obedient servant,

J. H. BACON,
Assistant Engineer.

Capt. W. M. BLACK,
Corps of Engineers, U. S. A.

SPECIAL REPORT ON PRESENT CONDITION OF JETTIES AT THE MOUTH OF ST. JOHN'S RIVER, FLORIDA.

UNITED STATES ENGINEER OFFICE,
St. Augustine, Fla., February 6, 1890.

GENERAL: I have the honor to submit the following report on the present condition of the jetties at the mouth of St. John's River, Florida, and of the river above the mouth, and further of the necessity for an immediate appropriation for the work, as called for in your indorsement dated January 31, 1890.

The condition of the work on July 1 is given in the Annual Report for 1889. Between that date and the date at which work under the contract was discontinued, in October, in the south jetty the superstructure was extended 800 feet with a narrow crest at mean low-water level (from Station 4100 to Station 4900); in the north jetty the ballasted mattress foundation was extended 1,008 feet (from Station 7983 to Station 8991) and the superstructure was extended 990 feet, with a crest at mean low-water level and varying there in width from 18 to 8 feet (from Station 6640 to Station 7630). Since October the south jetty shore extension has been built to its full height by hired labor. The sand has already begun to gather around it and it is believed that this jetty is now safe from the danger of being flanked and cut out from shore during storms. A small portion of the jetty is being capped with concrete by hired labor. This last work is to some extent experimental in character and is intended for a guide for more extended work in the future.

The channel which opened in 1885 close to the south jetty and which has been the main ship-channel since 1886 is not in the position which the channel made by the completed work will probably take. Its opening where it is, resulted naturally from the position of the south jetty with respect to the original unimproved ship-channel and from the order in which the jetties were constructed. The channel has been of great use to the shipping entering the St. John's River.

As the jetties have been extended the new channel has begun to open in the position which it is expected will be permanent, directly seaward from the natural mouth of the river. As this channel, known as the north jetty channel, has extended and enlarged, the volume of water carried by the ebb currents through the south jetty channel has been diminished, the depth on the bulkhead or crossing at its inner end has decreased, and the sand-bank (Ward's bank) on its north side has been rolled southward, diminishing its width.

This action has been very marked during the past six months and still continues. It is entirely normal and proper, and, if aided, will result in the opening of the permanent north channel completely across the bar. Unfortunately, at this critical time, jetty work is at a standstill; it being necessary to reserve the limited sum remaining in hand for shore-work and for an emergency fund.

The ebb currents are not yet sufficiently under control to open either channel completely. The sand eroded from the new channel is pushed seaward and distributed on the crest of the bar without being carried through. The south bar channel grows shoaler and narrower. There is even the possibility that it may be closed before the north channel is sufficiently opened.

The bar across the channels is, however, very short and its outer slope is very steep, showing it to be constantly and favorably acted upon by



St. Johns Bar, Fla., Annual Survey
1890
Plate No. 1. D

To accompany Annual Report of 1890
W. M. Black
Captain of Engrs U.S.A.

Improvement of

St. John's River, Fla.
1890

Showing the sites of the North and South Jetties,
and the progress made in their construction to June 30, 1890.

Scale of Feet
1500 0 500 1000 2000 3500 4000 5500

Surveyed, May 5,-June 6, 1890, under the direction of
Captain W. M. Black, Corps of Engrs, U. S. Army,
by
J. H. Bacon, Asst. Engr,
ASSISTED BY
F. W. BRUCE AND A. C. HARPER.

Characteristic Soundings only are given, and are expressed in feet and tenths, showing depths at mean low water

6ft Curve is shown thus: ———·———
12 - " " " ———··———
18 - " " " ———···———
24 - " " " ———····———
30 - " " " ———·····———

Fort George Island.

Fort George Inlet.

Pilot Town.

Maysport.

Beach House

Light House Reservation

Wreck Annabel Hyer

Current Sta. No. 3

Current Sta. No. 4

Current Sta. No. 2

Gauge No. 1

Gauge No. 2

Gauge No. 3

Gauge No. 4

Gauge No. 5

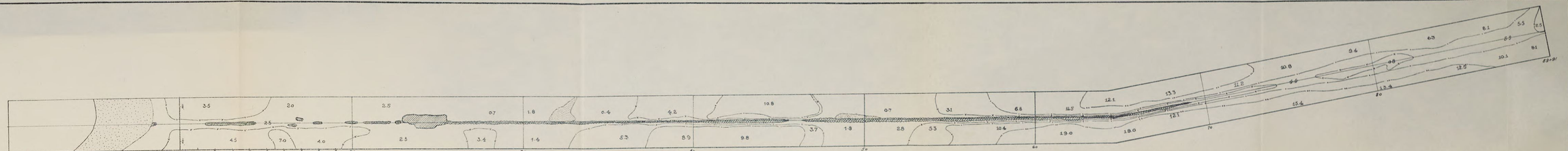
Atlantic House

Hanover Creek

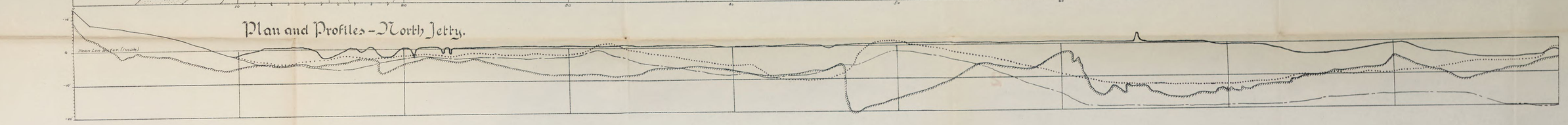
J. M. & P. Ry

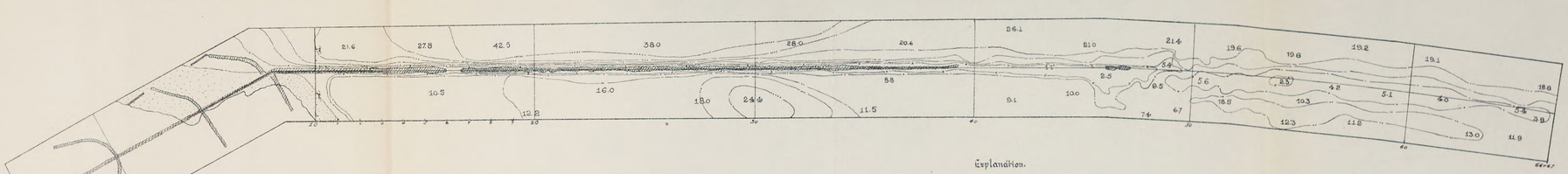
Photo-Lith. by L. Nitze & Co. Balto. Md.

St. John's Bay, Fla., Annual Survey, 1890. Plate No. 2. E

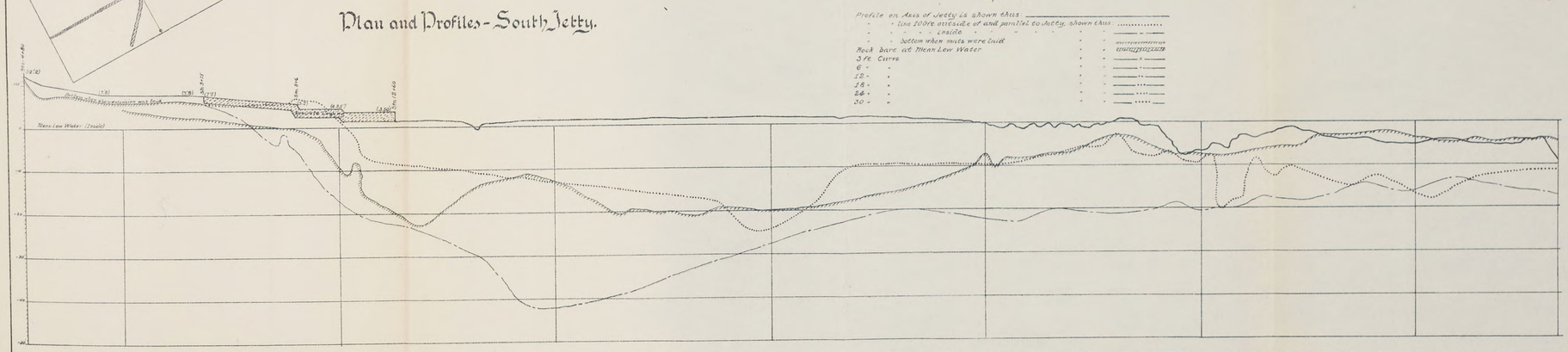


Plan and Profiles - North Jetty.





Plan and Profiles - South Jetty.



Explanation.

Profile on Axis of Jetty is shown thus _____

" " line 100 ft outside of and parallel to Jetty, shown thus .....

" " " inside " " " _ _ _ _

" " Bottom when mats were laid ////////////

Rock bare at Mean Low Water

3 Ft. Curve

6 " "

12 " "

18 " "

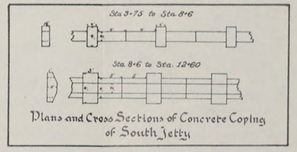
24 " "

30 " "

To accompany Annual Report of 1890

W. M. Black

Capt. of Engrs. U. S. A.



Plans and Cross Sections of Concrete Coping of South Jetty

Photo-Lith. by A. HOEN & CO., Balto., Md.

Eng 90.

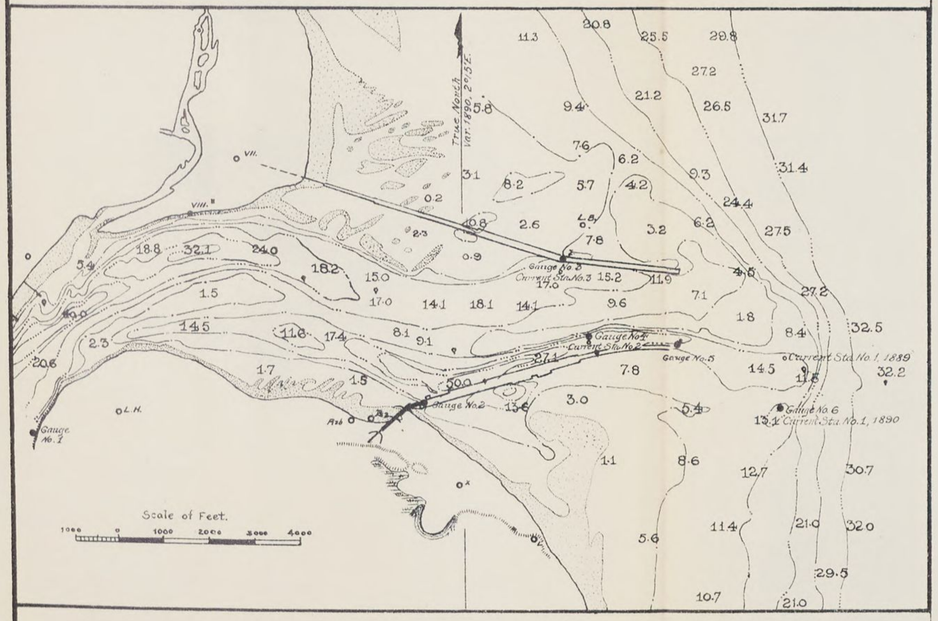
St. John's Bar, Fla., Annual Survey, 1890

Plate No. 3

F

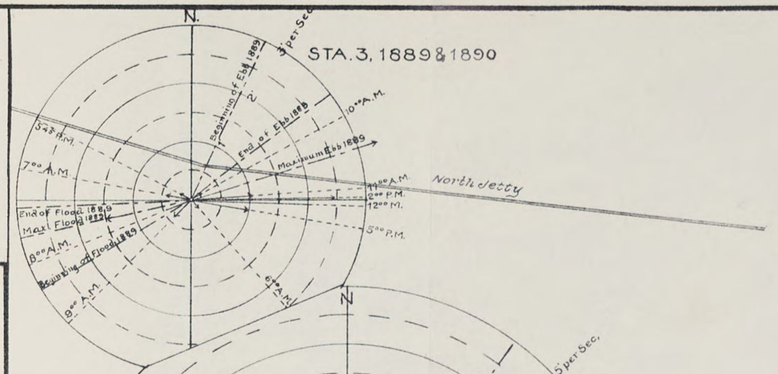
To accompany Annual Report of 1890

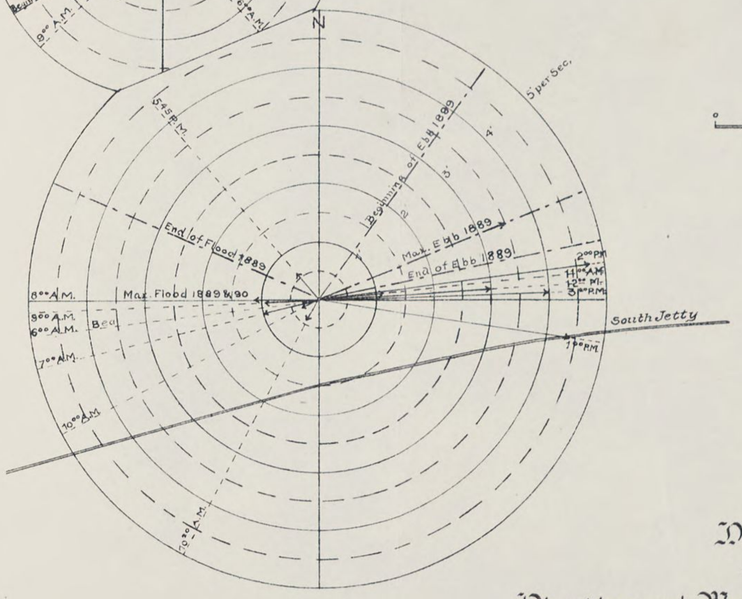
W. M. Black
Capt. of Engrs U.S.A.



Entrance to St. John's River, Fla. 1890

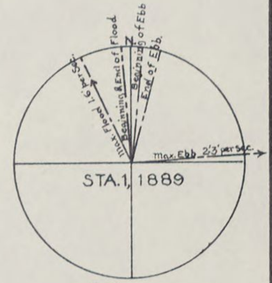
Soundings are expressed in feet and show depths at mean low water.
6 ft Curve is shown thus: ——·——
12 " " " " " ——··——
18 " " " " " ——···——
24 " " " " " ——····——
30 " " " " " ——·····——





STA. 2 1889 & 1890

Scale.
0 500' 1000' 1500' 2000'



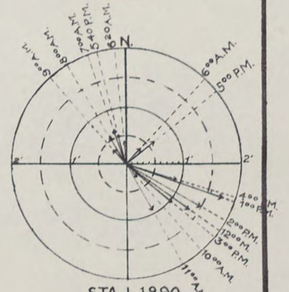
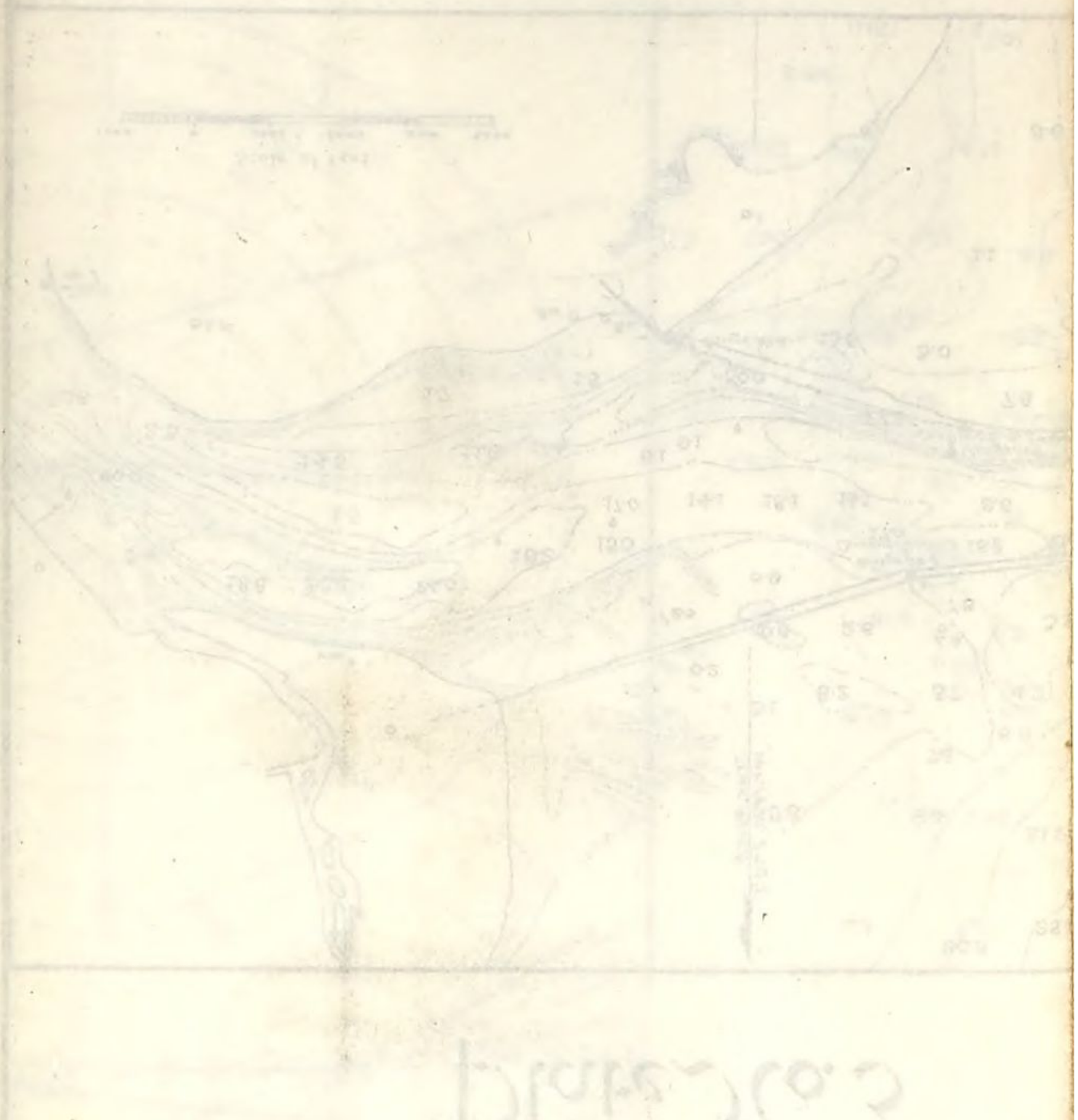


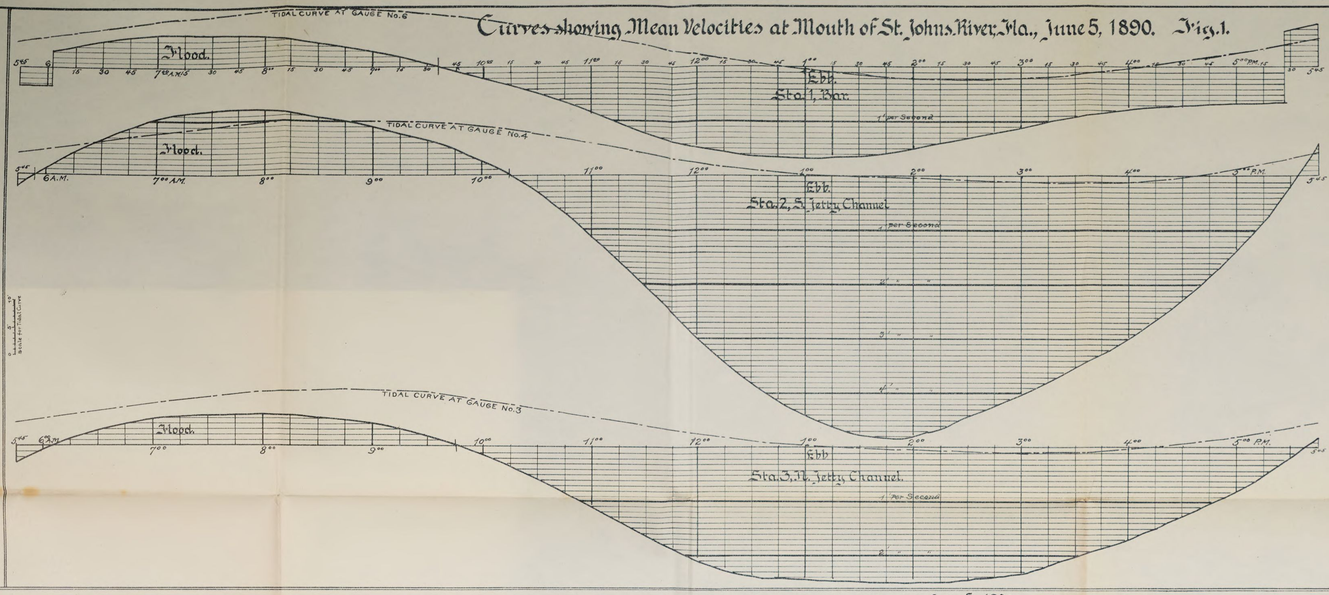
Diagram
Showing
Direction and Mean Velocities of Currents
And
Position of Stations with respect to the Jetties.

From Observations taken June 8, 1889 and June 5, 1890
Velocity is measured radially from center to arrow-head.

Photo-Lith. by A. HOEN & CO., Balto., Md.



Curves showing Mean Velocities at Mouth of St. Johns River, Fla., June 5, 1890. Fig. 1.



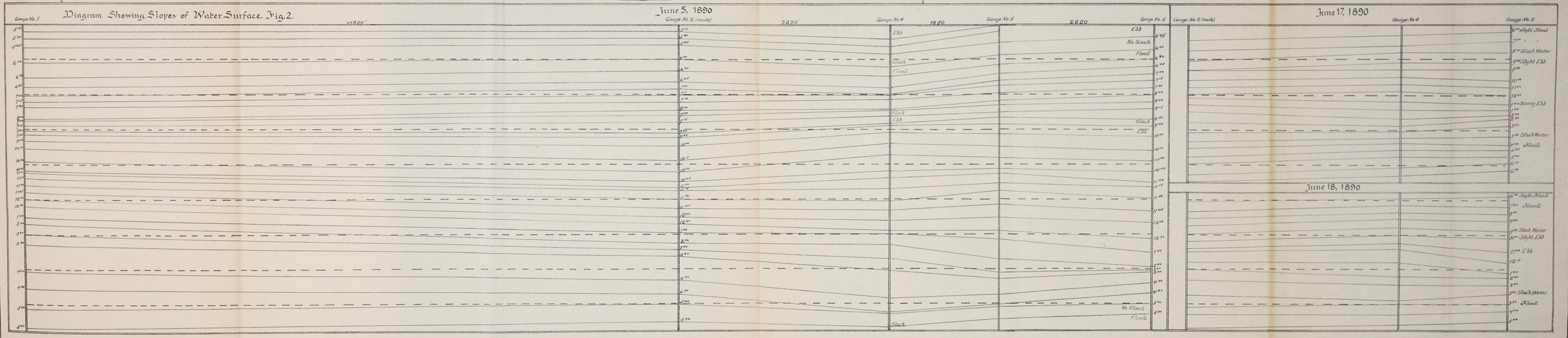
To accompany Annual Report of 1890.

W. H. Bixby
Captain of Engineers, U.S.A.

Tidal Record. Fig. 3

Time	June 5, 1890. Heights of water Surface, referred to Mean Low Water Zero						June 5, 1890. Differences in Elevations of Water Surfaces						June 17, 1890. Heights			June 17, 1890. Differences			June 18, 1890. Heights			June 18, 1890. Differences			Time.
No.	1	2	3	4	5	6	1-2	2-4	4-5	5-6	1-3	3-4	Gauge No. 4	5		2-4	4-5		Gauge No. 4	5		2-4	4-5		No.
0	1.20	1.40	1.40		1.33	1.03	-.20	+.20	.07																0
10	1.18	1.34	1.34		1.33	1.03	-.16	+.16	.01																10
20	1.20	1.34	1.34		1.33	1.03	-.14	+.14	.01																20
30	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																30
40	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																40
50	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																50
1	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																1
10	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																10
20	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																20
30	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																30
40	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																40
50	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																50
2	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																2
10	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																10
20	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																20
30	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																30
40	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																40
50	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																50
3	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																3
10	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																10
20	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																20
30	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																30
40	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																40
50	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																50
4	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																4
10	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																10
20	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																20
30	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																30
40	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																40
50	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																50
5	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																5
10	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																10
20	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																20
30	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																30
40	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																40
50	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																50
6	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																6
10	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																10
20	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																20
30	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																30
40	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																40
50	1.17	1.34	1.34	1.34	1.33	1.03	-.17	+.17	.01																50
H.W.	4.17	4.00	4.00	4.02	4.13	4.05	-.17	+.02	+.11	+.08			H.W.	3.58	4.00	+.42	-.42	H.W.	3.52	4.00	4.00	+.48	.00	H.W.	
L.W.	0.00	0.00	0.00	0.00	0.00	0.00	.00	.00	.00	.00			Height	0.00	0.00	.00	.00	Height	0.00	0.00	0.00	.00	.00	Height	

Diagram Showing Slopes of Water Surface. Fig. 2.



Eng 90.

Photo-Lith. by A. HOEN & CO., Balto. Md.

the currents. To open the permanent channel through it, and indeed to insure any channel across it, the jetties should be extended, and promptly.

The following work is imperatively needed: For the north jetty, to extend the foundation to Station 11250 and the low-water superstructure to Station 10000; for the south jetty, to extend the foundation to Station 8500 and the mean low-water superstructure to Station 7100. The estimated cost of this is $320,000. Later the jetties can be raised to full height and capped as far as desired. The estimated cost of this portion of the work is $145,000.

Since the recent discovery of extensive phosphate beds in South Florida the demand for a deep channel as far as Jacksonville has greatly increased. A rough estimate, based on recent surveys, shows that the cost of deepening the defective reaches to 15 feet at mean low water between Jacksonville and the mouth is $60,000, and that permanence can be given to the channels thus formed at an additional expense of $115,000. The present condition of the ship-channel between Jacksonville and the ocean may be summarized as follows:

Jacksonville to Dame's Point: Total distance, 12.25 miles; average channel width between 15-foot contours, 1,250 feet; minimum channel width, 500 feet; minimum mid-channel depth, 20 feet.

Dame's Point to Beacon No. 1: One mile below St. John's Bluff. Total distance, 8.5 miles; total length of defective channels, 2 miles; average width between 9-foot contours, 850 feet; minimum width between 9-foot contours, 300 feet; minimum depth of defective portions, 12.5 feet.

Beacon No. 1 to mouth: Total distance, 5 miles; average width between 15-foot contours, 870 feet; minimum width between 15-foot contours, 400 feet; minimum mid-channel depth (except at one place), 20 feet; depth at excepted place (one-half mile long), 15 feet.

Mouth to outer bar: Total distance, 2.8 miles.

Depth on middle ground between north and south channels, 10 feet.

Depth in south jetty bar channel, 11 feet scant.

Minimum width of south jetty channel, 275 feet.

Length between outer and inner 12-foot bar contours (south channel), 300 feet.

Depth in north jetty bar channel, 5 feet.

Distance between outer and inner 12-foot bar contours (north channel), 800 feet.

The estimated cost of completing the improvement so as to afford a channel 15 feet deep at mean low water between Jacksonville and the ocean may then be divided as follows:

Work immediately required:	
Jetties	$320.000
Dame's Point	60,000
Total	380,000
Additional work required to complete improvement:	
Jetties	$145,000
Dame's Point	115,000
Total	260,000
Grand total	640,000

These estimates are based on rates which would be obtained with large appropriations continuously available, and with a minimum ap-

propriation of $380,000 available at an early date. With such a sum the immediate success of the work may be deemed as certain as it ever can be for work of this character. With smaller appropriations the success of the work is endangered and its ultimate cost greatly increased.

Very respectfully, your obedient servant,

W. M. BLACK,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

P 2.

IMPROVEMENT OF VOLUSIA BAR, FLORIDA.

Operations for improving Volusia Bar, Florida, have been carried on at intervals since December, 1880, under six appropriations aggregating $25,500.

Volusia Bar is located at the south end or head of Lake George, about 162 miles by river from the mouth of St. John's River, at the point where the waters of the river flow into the lake.

An examination of Volusia Bar with a view to its improvement was made in March, 1879. A report thereon, dated July 16,1879, with plan of improvement, is printed as Appendix I 9, Annual Report of the Chief of Engineers for 1879.

This was modified as reported in the Annual Reports of the Chief of Engineers for 1882 and 1883, Appendixes J 11 and L 14, respectively.

Before its improvement the channel over the bar was very crooked, and had a least depth varying from $3\frac{1}{2}$ to $4\frac{1}{4}$ feet.

APPROVED PROJECT.

To establish and maintain a channel 6 feet deep across the bar by the increased velocity of flow produced by two converging jetties of brush and stone, assisted by dredging if necessary, and to define and protect the channel thus formed by rows of fender-piles.

In 1887, this project was modified to limit the depth to the 5 feet already attained, as that depth is sufficient for the steamers navigating the Upper St. John's River and is as great as can be carriod over the bars between Lake Monroe and Lake George.

OPERATIONS PRIOR TO JUNE 30, 1889.

The total amount expended up to June 30, 1889, including liabilities then outstanding, was $24,795.50. Two jetties had been built, starting from opposite sides of the river bank at the south edge of the lake and converging until on the bar the clear channel way between them was 230 feet wide. The east jetty is 3,400 feet long, and is built to the level of mean low water for 2,930 feet from the shore. The west jetty is 2,200 feet long, of which a length of 1,940 has its crest at the level of mean low water. Two rows of firmly set piles, provided with waling strips, confine boats to a 100-foot channel across the crest of the bar.

The channel obtained by these means is of sufficient width and depth for all boats using the river, and is easily followed.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

An examination of the jetties and bar was made on March 10. The available mean low-water depth on the bar was found to be 5 feet. The jetties, which had been built originally to the level of mean low water, have settled somewhat. The west jetty was found to be in fairly good condition, having only a few small gaps; the average height of the crest was 0.7 feet below mean low water.

The condition of the east jetty is not so good. The average height of the crest is 0.7 feet below mean low water, but there are several large gaps, where the height of the crest varies from 1.5 feet to 4.0 feet below mean low water, and in some of these the rock is entirely covered with sand.

The piling and waling strips forming the protection fences are in good condition, with the exception of one break in the west fence. This is between the 5th and 6th cluster of piles, counting from the south end. The first pile north of the 5th cluster, and the waling strips attached were torn away, during a fog, by one of the river steamers in December, 1889.

As the small amount of money available for this work was not sufficient to repair thoroughly both jetties, it was decided to expend a portion of this sum in building up the west jetty, as it exercises the greater controlling influence on the current, and as the money available was sufficient to place it in good repair. Accordingly, on March 26, a lighter load of stone (100 cubic yards) was placed on the west jetty, raising it to a height of 1 foot above mean low water from Station 9 to Station 19.

It is estimated that about 400 cubic yards of stone would be required to fill up existing gaps and raise the jetties to mean low water. It is not recommended, however, that this amount be placed on the jetties at any one time as long as the depth across the bar, which is sufficient for existing needs, remains in its present condition. Five hundred and fifty dollars will be needed for repairs during the coming fiscal year.

This work is located in the collection district of St. John's. Jacksonville is the nearest port of entry. Nearest light-house is Volusia Bar Light. Nearest fort is Fort Marion.

Money statement.

July 1, 1889, amount available		$704.50
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$659.02	
July 1, 1890, outstanding liabilities	27.25	
	686.27	
July 1, 1890, balance available		18.23
Amount appropriated by act of September 19, 1890		500.00
Amount available for fiscal year ending June 30, 1891		518.23
Amount (estimated) required annually for maintenance of work		500.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		500.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

Commerce of Volusia Bar, Florida, during the year ending December 31, 1889.

Articles.	Quantity.	Estimated value.	Gross tonnage.
Fertilizers ..... tons..	1,430	$31,400.00	1,430
Fruits..... boxes..	201,750	453,937.50	8,070
Grain, flour, etc ..... tons..	1,800	63,000.00	1,800
Hides ..... number..	500	900.00	4½
Merchandise ..... tons..	1,942	194,200.00	1,942
Vegetables ..... boxes..	47,033	58,791.25	941
Passengers..... number..	18,000	45,000.00	1,350
Total	.....	847,218.75	15,537½

Vessels.	No.	Tonnage.
Steamer average three trips weekly:		
City of Jacksonville.....	1	459
H. B. Plant.....	1	288
Gov. Safford.....	1	307
Steamer occasional trips:		
Du Baya.....	1	395
Welaka.....	1	209
Everglades	1	413

A large number of yachts frequent the bar. No record kept.
Average draught of water, 4 feet.
Total trade of neighborhood carried by water. Probable increase of trade were the improvement completed, 50 per cent.

Remarks.—All points on the St. John's River are dependent on water transportation. The above includes only trade by water over Volusia Bar.

HENRY MARCOTTE.

P 3.

IMPROVEMENT OF ST. AUGUSTINE HARBOR, FLORIDA.

St. Augustine Harbor lies on the east coast of Florida, about 47 miles south of the St. John's River. It is formed by the junction of two rivers, or rather salt-water lagoons, the Matanzas and Tolomato rivers, which run parallel to the coast, and there unite to break through the line of sand-hills into the sea. The total length of the Tolomato River is about 20 miles, and of that part of the Matanzas River which receives and discharges across the St. Augustine Bar, 12 miles. The San Sebastian River, another lagoon, almost surrounds St. Augustine, and opens into the Matanzas River about 3 miles from its mouth. These lagoons vary in depth from 20 to 30 feet for several miles from the mouth and in width from 300 to 500 yards. They form large tidal basins, filled and emptied through the channels across the bar. The rise of tide at St. Augustine varies from 4 to 6 feet, and the currents generated have maintained two or more channels across the bar with a least depth of from 6 to 9 feet at low water. The positions of these channels are continually shifting between the south end of the mainland east of the Tolomato River (north beach or north point) and the cape on St. Anastasia Island $2\frac{3}{4}$ miles to the south. The harbor forms an excellent sheltered anchorage, but the shifting nature of the bar and the shallow water on its crest have presented so many difficulties to mariners that the commerce of the port has been greatly hampered, and as until

recently the city has had no railroad communication with the interior, it has been limited to the necessary supplies for St. Augustine.

In the river and harbor act of August 11, 1888, $35,000 were appropriated for the improvement of this harbor, subject to the recommendations of a board of engineer officers. In accordance with the recommendation of the Board it was directed by Department letter of February 20, 1889, that the funds available should be used in checking the erosion of the shores on Anastasia Island and North Point on the two sides of the entrance.

PROJECT.

The approved project provided for the construction of spur-jetties or groins of concrete and riprap on brush foundation mattresses, with suitable wing-walls of riprap.

OPERATIONS DURING FISCAL YEAR ENDING JUNE 30, 1890.

Work on the project was begun in October, 1889, by hired labor, using materials purchased by contract. Work ceased, due to the exhaustion of the appropriation, on June 30, 1890.

Three groins have been built. One on Anastasia Island near the north boundary of the light-house reservation, one on the east side of the point about 2,000 feet from the point, and one on the point. The groin on Anastasia Island is 341 feet long, and has a wing on each side. From Station 0 to Station 50 (at the crest or inner edge of the beach) it is a riprap revetment 16 feet wide. From Station 50 to Station 263 its cross-section consists of a foundation of brush fascines, with a superstructure of oyster shell and riprap stone, capped with a concrete block made in place. . The concrete blocks are 24 to 30 inches thick, according to exposure, 5 feet long, measured on the axis of the groin, and 6 feet wide at base, except each third block, which is 4 feet long and 8 feet wide. They are 2 feet wide at the crest and have side slopes of 1 on 2. The riprap is piled to the level of the edges of the blocks. The crest of this portion of the groin varies from 12.5 to 1.5 feet above mean low water. From Station 263 to Station 341 the superstructure is of riprap with a crest 1.5 feet above mean low water, sloping at the outer end gradually to the mattress foundation. The wings are of riprap with a row of concrete in barrels sunk on end flush with the crest to give greater stability. Four thousand four hundred lineal feet of 9-inch brush fascines, 2,596 square yards of fascine mattresses, 1,983 tons of stone, 358 cubic yards of oyster shell and 104 cubic yards of concrete were used in the construction.

The main groin on the North Point is 541 feet long. It starts at the sand hills at the level of storm-high tides. Its crest from Station 0 to Station 197 is at reference 11.39 feet above mean low water, and from Station 197 to Station 541 the reference varies from 11.39 feet to 6.05 feet. Its cross-section is the same as the Anastasia Island groin; the thickness of the concrete blocks varying with the exposure from 24 to 36 inches. This groin contains 15,400 lineal feet of 9-inch brush fascines, 1,827 tons (2,000 pounds) of stone, and 560 cubic yards of oyster, and 318.2 cubic yards of concrete.

A sand-catch constructed in plan similar to the Newburyport, Mass., catch, extends the jetty 290 feet to the west and joins it to a range of sand dunes which crosses the island. In this catch, wire is used for holding the brush in place.

The groin on the point is similar to the others in general construction, but is of lighter cross-section and lower, the concrete blocks being placed directly on the brush foundation.

MATERIALS AND METHODS.

The stone used is the Florida limestone. It is furnished in irregular pieces, weighing from 1 to 220 pounds. The oyster shells were obtained from a shell-mound near the city. Mingled with them were many bones and fragments of Indian pottery. The concrete was made of cement, beach-sand and coquina gravel. For a detailed description of the method of construction followed, attention is invited to the appended report of Lieut. D. D. Gaillard, Corps of Engineers.

In this work an effort has been made to obtain as much information as possible regarding the use of concrete in jetty work under the conditions prevailing on this coast. Certain concrete placed in sea water at St. Augustine in the winter of 1886 having deteriorated badly, the cement used was selected as far as possible from brands which were known to have stood sea action successfully for at least five years.

A tensile strength of 30 pounds per square inch after one week in air was adopted as the minimum strength to be allowed for the cementing material of the concrete (the cement as diluted by sand and other fine materials). The proportions of the ingredients were determined by this rule. In practice the Portland cement concretes had greater strength and the Rosendale cement concrete less strength than this standard. During the progress of the work it was shown that this tensile strength is as near as possible the minimum which will withstand the wash of waves. In exposed positions this strength should be attained in less than a week, the time varying with the exposure. The proportion used and the cost of the various kinds of concrete are given in Lieutenant Gaillard's report. It was shown that it is quite possible to lay concrete in mass in a sea-way, provided the concrete is protected everywhere from the actual scour of the water.

WAVE ACTION.

During the progress of the work observations were made on the effect of wave action. The amount of compression of a spring by the blow of a wave was measured by a simple and cheap form of dynamometer devised by Lieut. D. D. Gaillard, and described in his report.

Some of the methods and effects of wave action as shown by experience here and at the mouth of the St. John's River may be summed up as follows:

A wave may act on the jetty directly by a blow, or a push, by a blow and a push combined, and indirectly by a pull by compressing the air in the voids of the masonry, by upward pressure due to the difference of head produced on the two sides of the jetty, or by a combination of these actions.

The direct action measured in the dynamometers had effects equal to pressures varying between 190 pounds and 753 pounds per square foot. This action took place when a wave broke directly on or slightly in advance of the jetty. This also compressed the air in the voids of the jetty. Where the bottoms of the concrete molds were not tight and the concrete was weak a curious vertical cracking and flaking was at times discovered, produced most probably by this action. Jets of water and sand were sometimes projected up from the cracks in the jetty to some height.

The indirect action took place generally during the rush back of the water to meet an advancing wave. In one instance when the direction of wave motion was nearly perpendicular to the jetty crest, and the general level of the water slightly below the crest just before the waves broke the difference of head on the two sides of the jetty was fully a foot and the velocity of the water rushing back across the jetty to meet the advancing wave was very great. The following are some observed effects of wave action. The maximum height of any wave observed striking the work was 6 feet. Waves of this height reached the shore only at high water since as near as could be observed waves broke in water whose depth equaled their height. Up to a height of about 2 feet above mean low water riprap weighing 40 to 50 pounds was but little disturbed. Above this limit, to the height of 10 feet, the highest point observed, riprap varying in weight from 40 to 220 pounds could not be held at any slope.

An isolated piece of concrete, weighing 350 pounds and resting on its felt base 1.7 square feet in area, with its center of gravity 7 feet above mean low water, was moved several feet by breakers, whose crests were about 7½ feet above mean low water. These breakers measured 3½ feet from hollow to crest. The most constant effect of the breakers was experienced near the level of the crest of the work, 6 feet above mean low water; but undoubtedly the maximum effect would have been felt at an elevation considerably greater. All of that portion of a mound or wing, composed of riprap (varying in weight from 40 to 220 pounds) tightly chinked with oyster shells, lying between 4 and 6 feet above mean low water (no matter what side slopes the riprap was given), would be carried away in a single tide whenever breakers greater than 4 feet in height struck it fairly. In one case a block of concrete weighing 527 pounds was elevated 1.3 feet by the action of a single breaker. During the same tide it was moved 23 feet inshore. A dynamometer within 8 feet of its original position recorded a maximum pressure of 575 pounds per square foot during this tide. * * * A piece of concrete weighing 200 pounds was lifted vertically to a higher level than that of the water surface by a wave which broke just in front of it. (Report of Lieutenant Gaillard.)

Another block of concrete weighing about 1,600 pounds was lifted from its bed vertically at least 14 inches and then moved several yards. (St. John's Bar.)

EFFECT OF THE GROINS.

A survey made on June 25 shows the effect of the groins to be as follows:

Groin No. 1, Anastasia Island, has stopped the erosion in its vicinity and built out the shore high and low-water lines for a distance of about 1,500 feet north and 500 feet south of the groin.

Groins 2 and 3, on North Point, have checked the washing away of the point, and have built out the low-water line. Commencing at a point about 1,500 feet north of groin No. 3 and extending around the point, a total distance of 2,800 feet, the low-water line has been pushed seawards a distance varying from 50 to 200 feet.

The high-water line has been but little changed as yet except in the immediate vicinity of the groins, where it has been pushed seaward about 110 feet at groin No. 2, and about 30 feet at groin No. 3.

But little sand has been caught by the sand-catchers, owing to the fact that since they were completed the weather has been quite calm and very little sand has been moved by winds.

FUTURE OPERATIONS.

Judging from the effects produced by the work already done, it seems entirely probable that the erosion of the shore in the vicinity of the harbor entrance would be completely checked by extending groin No.

2 150 feet; constructing a groin similar to groin No. 3 about 1,000 feet south of that groin, and another groin similar to groin No. 1 on Anastasia Island, opposite North Point; together with such light intermediate works as experience may show to be necessary.

The estimated cost of this work is $30,000.

The work has been in local charge of Lieut. D. D. Gaillard, Corps of Engineers, and its success is largely due to his efficient management of the men and materials.

St. Augustine is in the collection district of St. Augustine, which is the nearest port of entry. The nearest fort is Fort Marion. The St. Augustine Light is the nearest light-house.

Money statement.

July 1, 1889, amount available		34,371.40
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$32,688.93	
July 1, 1890, outstanding liabilities	541.47	
		33,230.40
July 1, 1890, balance available		1,140.67
Amount appropriated by act of September 19, 1890		20,000.00
Amount available for fiscal year ending June 30, 1891		21,140.67
Amount (estimated) required for completion of existing project		10,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		10,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

COMMERCIAL STATISTICS.

Commerce of St. Augustine Harbor, Florida, during the year ending December 31, 1889.

Articles.	Quantity.	Estimated value.	Gross tonnage.
Coal ..... tons	750	$6,000.00	750
Fertilizers ..... do	396	9,900.00	396
Fruits ..... do	230	.....	.....
Do ..... boxes	459	7,768.00	248
Grain, flour, etc ..... tons	1,143	55,122.00	1,143
Lumber (sawed) ..... B. M	3,015,500	60,320.00	6,785
Merchandise ..... tons	10,766	1,076,600.00	10,766
Vegetables ..... barrels	2,800	.....	.....
Do ..... boxes	728	6,382.40	290
Passengers ..... number	54,472	68,090.00	4,085
Building materials ..... tons	2,950	118,000.00	2,950
Total	.....	1,408,182.40	27,413

	Number.	Aggregate tonnage.	Draught.
			Feet.
Schooners:			
Coastwise	24	5,502	*9
Foreign	6	1,216	6 to 12
Yachts:			
Steam	7	700	4 to 10
Schooner	3	150	
Sharpies	4	20	

*Average.

Estimated percentage of total trade of neighborhood, as given above, carried by water, 50.

Probable increase of trade were the improvement completed, 100 per cent.

REMARKS.—Much of the freight, especially coal and building material, was transshipped by rail from Jacksonville, Fla., owing to lack of water over the bar at St. Augustine Harbor. Exports in lumber would be largely increased on the completion of the contemplated improvements; transportation to other ports by rail cripples at least this one branch of trade.

HENRY MARCOTTE.

REPORT OF LIEUTENANT D. D. GAILLARD, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
St. Augustine, Fla., June 3, 1890.

SIR: I have the honor to submit the following report in compliance with your verbal instructions directing me to report on the following subjects, in connection with the work of improvement in St. Augustine Harbor, Florida, under my immediate charge:

1. Methods of constructing the groins.
2. Proportions adopted for concrete.
3. Strength at various ages of different kinds of concrete.
4. Cost of concrete.
5. Wave action.

The groins constructed were three in number, and for convenience will be designated as No. 1, No. 2, and No. 3.

Groin No. 1 is situated on Anastasia Island near the north boundary of the United States light-house reservation, No. 2 projects from North Point, and No. 3 is situated on North Beach about 2,000 feet north of the Point.

The same class of materials was used in the construction of all three of the groins, viz, Brush fascines, riprap stone, oyster shells, and concrete.

METHOD OF CONSTRUCTING THE GROINS.

The methods of construction employed varied with the depth of water and degree of exposure to wave action.

(1) When the original surface of the ground on the site of the work was at a greater elevation than the high-water level of ordinary storm tides no fascines were used, and this portion of each groin (the shore end) was constructed as follows: First, the boxing for the concrete hearting was nailed to stakes driven firmly into the ground and well braced; then a low, flat bed of oyster shells, well rammed, was built up to the level of the concrete boxing. The width of the top of this bed of shell was about 5 feet greater than that of the boxing. The side slopes were about one on two. All that portion of the shell bed lying outside of the boxing was then covered with a layer of riprap about 2 feet thick.

The boxing was divided into lengths of 4 feet and 5 feet by plank partitions 2 inches thick, in order to form concrete blocks of short length, which would be capable of independent settlement. Every third box was 4 feet in length, and was made 2 feet wider than the two preceding ones in order to prevent the travel of the riprap alongside the groins.

Into the boxing thus prepared concrete-in-mass was dumped and well rammed. Each block of concrete as completed had a cover of 1-inch plank nailed on it, thus permitting the groin to be used as a run-way for wheelbarrows.

(2) Where wave action was slight and the water less than waist-deep, 9-inch brush fascines of suitable length were laid alongside of each other at right angles to the axis of the groin and ballasted with a layer of riprap 1 foot thick. After this the method of construction of the groin differed from that above described only in the fact that the lower edge of the boxing was carried down 6 inches below the proposed level of the base of the concrete block, and that the top of that portion of the shell bed lying outside the boxing was 6 inches higher than this base.

(3) Where the depth was considerable, the current swift, and the wave action comparatively light (which was the case only at groin No. 1) the foundation course consisted of mats of brush fascines, ballasted with riprap stone. These mats were essentially the same as those used at St. John's Bar, Florida, except that in the last mats made the fascines on each side of the mat extended about 8 feet beyond the pole grillage, experience at this locality having shown that when the fascines did not extend beyond the grillage, they were supported so firmly by the lower grillage, that the bottom of the lower layer of fascines lacked from 6 to 8 inches of touching the bed of the stream, and consequently the action of the mat in catching and retaining sand was

very slow. These mats were launched and sunk in the usual manner. After this was done the method of construction, when shell was available, was that described in case 8. When no shell was available, the boxing was provided with a bottom of 1-inch plank to prevent the concrete from being washed out. In all other respects the method of construction was the same.

(4) The only other case encountered in the progress of the work, and by far the most difficult one to deal with, was where the depth never exceeded 5 or 6 feet, but wave action was always heavy about the time of high water. This occurred principally at groin No. 3 and extended from the shore mean high-water line seawards. The effect on the groin of the increased wave action (when an attempt was made to continue the same method of construction described in case 2) was as follows:

The riprap ballast would be moved off the fascines and the latter then cast ashore by the waves; the shell bed, and much of the riprap, washed completely away; the boxing thrown out of place or knocked to pieces, and a deep "slough" cut around the unfinished end of the groin, beyond the outer fascines.

The methods successfully adopted to overcome these difficulties were as follows:

The fascines were fastened together with ½-inch manilla rope in as many places as seemed necessary and were then ballasted with specially heavy riprap and with concrete in barrels. The shell bed was replaced by a bed of riprap, chinked with oyster shell and then covered with a layer of shell about 6 inches thick. The top of this layer of shell was 6 inches higher than the base of the concrete block and about 12 inches higher than the lower edge of the boxing. The boxing was then filled with riprap and allowed to remain in this condition until at least one high tide had settled and compacted the bed of riprap and shell.

The boxes were kept from being knocked out of place by being filled with riprap, as just described, and by having an extra amount of specially heavy riprap piled alongside of them and around the end of the last box. This generally served to prevent the boxing from being wrecked to pieces, although from time to time during the progress of the work damage was done to some of the boxes not yet filled with concrete.

The cutting of the "slough" around the outer end of the groin could always be prevented when the foundation of ballasted fascines could be extended from 40 to 60 feet in advance of the boxing. This, however, was not always practicable, owing to the fact that the fascines could only be laid about the time of low water.

In this portion of the work great care was necessary to prevent the concrete from being washed out by wave action before it had time to set. The boxing was made as tight as was practicable with unplaned plank, and from three to six boxes, filled with riprap, as previously described, were always prepared in advance, so as to have a tight, compacted bed for the concrete, and well-tested boxing.

Due to these precautions the whole amount of concrete lost by being washed out before having set, was but 15 cubic feet; 12 cubic feet of Rosendale concrete and 3 cubic feet of Portland concrete.

Several concrete blocks at groins Nos. 1 and 3 were made in boxing provided with a bottom of 1-inch unplaned plank, resting on riprap only. Although in about the most exposed positions at these works, no concrete was washed out.

This, with previous experience on these works, proved conclusively that carefully made boxing of unplaned plank was amply tight enough to prevent the washing out of concrete through the boxing as long as the latter was undamaged.

PROPORTIONS ADOPTED FOR CONCRETE.

After many tests the following proportions were adopted in making the concrete:

Brand of cement.	Proportions by measure.		
	Cement.	Beach sand.	Coquina gravel.
Portland:			
Anchor	1	4	6½
Sphinx	1	4	6½
Dyckerhoff	1	4	6½
Rosendale:			
F. O. Norton's	1	1	2¾
Fisher's "U. S. G"	1	2	4
Hydraulic lime of Teil	1	2	4

NOTE.—The sand was of poor quality, being round and so fine as to pass almost the same test for fineness as the cement itself. No other kind, however, could be procured.

These proportions proved satisfactory in all respects.

STRENGTH AT VARIOUS AGES OF THE DIFFERENT KINDS OF CONCRETE.

As nearly nine-tenths of all the concrete was made from the Anchor brand of Portland cement and the F. O. Norton brand of Rosendale cement, the concrete tests were confined almost entirely to those brands. The briquettes tested were 4 square inches in area at the breaking section and were made from the regular working batches of concrete, with the proportions just given.

Tensile strength of concrete.

PORTLAND CONCRETE.

No. of briquettes, broken.	Age in days.	Remarks.	Mean tensile strength in pounds per square inch.
3	1	Mixed with fresh-water	6
3	2	....do	23
2	3	....do	37
2	4	....do	33
15	7	Mixed with salt-water	40
2	9	....do	54
3	14	Mixed with fresh-water	59
3	21	....do	70

ROSENDALE CONCRETE.

3	1	Mixed with fresh-water	5
3	2	....do	6
3	3	....do	7
3	4	....do	12
4	6	....do	14
7	7	Mixed with salt-water	4
2	9	....do	13
3	14	Mixed with fresh-water	16
8	21	....do	38

Experience showed that submergence in sea-water retarded the setting of the Rosendale concrete considerably, but affected the Portland concrete only to a small extent. The same thing was true in regard to the use of fresh and sea water in mixing these concretes, as shown in the preceding table. The briquettes tested were kept in air after being made, and as the tests were continued it was found that they showed no increase of strength with age after three weeks; in a few cases a marked decrease even was observed. To ascertain whether this was due to actual deterioration or to lack of moisture, the briquettes then on hand, which had been kept in air three weeks, were divided in two groups. One group was kept dry, as before, and the other group moistened three times at intervals of four or five days. Corresponding briquettes from the two groups were then tested. In every case and with both kinds of concrete the wetted briquettes were from 50 to 100 per cent. stronger than those which had been kept dry, thus clearly showing the cause of the apparent deterioration.

This difficulty can be overcome in any future tests by burying the briquettes in sand on the beach to a depth of 2 or 3 feet, as is sometimes done abroad.

COST OF CONCRETE.

The cost of all the concrete is given in detail in the following table:

Cost of concrete.

GROIN No. 1.

Brand of cement.	Quantity used.	Sea sand used.	Coquina gravel used.	Concrete made.	Cost of cement on spot.	Cost of sand.	Cost of Coquina gravel.	Total cost of materials.	Labor, mixing, wheeling, and ramming concrete.	Labor, carpenter, boxing, etc.	Lumber and nails.	Transportation of workmen.
Portland:	*Bbls.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*								
"Sphinx"....	50	24.4	39.7	42.22	$155.00	$6.40	$10.79	$172.19	$60.83	$25.98	$25.78	$4.35
"Anchor"...	18	8.8	14.3	15.00	55.80	2.30	3.88	61.98	21.63	9.23	9.16	1.60
Rosendale:												
F. O. Norton's	100	12.6	33.6	41.48	165.00	3.20	8.86	177.06	63.76	25.52	25.33	4.30
Fisher's "U. S. G.".....	5	1.2	2.4	2.41	11.45	.32	.66	12.43	3.47	1.48	1.47	0.25
Lime of Teil...	*10	1.5	3.0	2.89	19.20	.40	.82	20.42	4.06	1.78	1.76	0.30
Total	183	48.5	93.0	104.00	406.45	12.62	25.01	444.08	153.75	63.99	63.50	10.80

* Bags.

GROIN No. 2.

Portland; "Anchor"	70½	82½	40.0	64.55	76.70	263.18	.....	29.01	292.22	105.262	85.60	46.05	(†)
"Sphinx"	7											
"Dyckerhoff".	5											

GROIN No. 3.

Portland:												
"Anchor" ...	212.5	106.3	193.2	196.41	656.62	.....	320.10	976.72	289.62	169.45	177.11	(†)
Rosendale:												
F. O. Norton's	300	38.8	119.8	121.79	565.80	.....	215.77	781.57	191.16	105.08	109.83	(†)
Total	512.5	145.1	313.0	318.20	1,222.42	.....	535.87	1,758.29	480.78	274.53	286.94	.....

GROIN No. 1.

Brand of cement.	Cost per cubic yard of concrete.					
	Materials.	Labor, mixing, and ramming.	Labor, carpenter, boxing.	Lumber and nails.	Transportation of workmen.	Total cost per cubic yard.
Portland:				*Cents.*	*Cents.*	
"Sphinx".....	$4.079	$1.441	$0.615	61	10.4	$6.849
"Anchor".....	4.132	1.442	.615	61	10.6	6.905
Rosendale:						
F. O. Norton's.....	4.268	1.537	.615	61	10.3	7.133
Fisher's "U. S. G.".....	5.158	1.440	.615	61	10.4	7.927
Lime of Teil.....	7.066	1.441	.616	61	10.4	9.837

GROIN No. 2.

Portland: "Anchor" ..... "Sphinx"..... "Dyckerhoff".....	3.810	1.372	1.116	60.1	(†)	6.899

GROIN No. 3.

Portland: "Anchor".....	4.973	1.475	.863	90.2	(†)	8.213
Rosendale: F. O. Norton's.....	6.417	1.570	.863	90.2	(†)	9.752

† Not included.

Cost of concrete—Continued.

AVERAGE COST OF ALL CONCRETE.

Where made.	Total amount of concrete.	Total cost.	Average cost per cubic yard.	Portland concrete made.	Rosendale concrete made.	Lime of Teil concrete made.	Average cost per cubic yard Portland concrete.	Average cost per cubic yard Rosendale concrete.	Average cost per cubic yard lime of Teil concrete.	Remarks.
Groin :	*Cu. yds.*			*Cu. yds*	*Cu. yds*	*Cu. yds*				
No. 1....	104.00	$736.12	$7.078	.....	.....	.....	.....	.....	.....	Superintendence not included in cost.
No. 2....	76.70	529.13	6.899	.....	.....	.....	.....	.....	.....	Superintendence and transportation of workmen not included.
No. 3....	318.20	2,800.54	8.801	.....	.....	.....	.....	.....	.....	Do.
Grand total.	498.90	4,065.79	8.149	330.33	165.68	2.89	$7.673	$9.070	$9.837	

The carpenter was paid 28 cents per hour and the laborers 15 cents per hour. Lumber cost $15.50 per 1,000 feet, B. M., delivered at the works. Nails cost $2.60 per keg.

The concrete was all mixed by hand, using shovels alone. The materials for the batch were turned three times when dry, water was then added, and four additional turnings given. The concrete in every case was carried to the desired spot in wheelbarrows, using the groins as run-ways. Seventy-five barrow loads of loose concrete made 80 cubic feet of rammed concrete. A good distribution of the working party was: One man measuring materials, filling barrows, etc.; 4 men mixing (2 at one time); 1 man wheeling (when the distance did not exceed 200 feet), and 2 men ramming. An additional man could be kept busy wheeling for about every 250 feet of increase in the distance between the mixing platform and blocks to be made.

The total cost of all tools used in mixing, wheeling, ramming, and covering concrete was about $30.

The capacity of Norton's Rosendale cement barrel was 3.4 cubic feet; Portland cement barrel, "Anchor" brand, 3.35 cubic feet; "Sphinx" brand, 3.25 cubic feet.

Measured loose in quantities of 2 cubic feet at a time, a barrel of Norton's Rosendale gave 4.37 cubic feet of loose cement; a barrel of Portland, "Anchor" brand, gave 3.65 cubic feet; "Sphinx" brand, 3.71 cubic feet. A sack of lime of Teil gave 2.1 cubic feet.

One cubic foot of Portland concrete, of the adopted proportions, weighed 143.2 pounds, when newly made, and 137 pounds when one month old. One cubic foot of P. O. Norton's Rosendale concrete weighed 133.3 pounds, and 131 pounds at like ages.

WAVE ACTION.

Wave action furnished the most serious obstacle that was encountered during the progress of the work. It effects were greatest at Groin No. 3, though experienced to a considerable extent at both Groins 1 and 2. At these two places wave action seemed to exert about the same effect.

Being desirous of obtaining some measure of comparison for the force exerted by breakers at Groin No. 3, it became necessary to procnre some form of dynamometer. Experience with the sand-charged breakers of this coast made it almost certain that the marine dynamometer devised by Mr. Thomas Stevenson would, if set up at the desired spot, become so choked with sand as to be inaccurate.

After some difficulty I devised the following form of dynamometer, which you authorized me to have constructed.

A steel plate 8 inches by 18 inches (1 square foot) in area and one-fourth inch thick was firmly bolted to two elliptical steel springs similar to the best class of springs used under wagon-seats. These springs were placed 6 inches apart from center to center. Their planes were parallel to each other and to the length of the plate and at right angles to the plane of the plate. Protruding to the rear from the center of the plate, and perpendicular to it, was an iron rod three-eighths inch in diameter and 15 inches long.

This form of dynamometer was constructed in a few hours and cost about $5.

The dynamometer, as set up, was fastened to an upright post 8 inches by 8 inches in cross-section by four 9-inch bolts, two of which passed through each spring and then

through the post. The iron rod passed through the post and about 1 inch beyond its rear face, terminating in a horizontal groove. This groove extended almost the entire length of a piece of 2-inch by 4-inch timber, mortised into the rear face of the post and parallel to the iron rod. The groove was partly filled with melted paraffine and a cover lashed over it. The maximum compression between readings was recorded plainly and accurately on the surface of the paraffine.

After being fastened to the post, and before being set in place, the dynamometer was rated by piling weights on the plate and observing the corresponding compressions. Another rating, made about four months later, showed no appreciable change in the elasticity of the springs. From time to time the entire apparatus was covered with a coat of coal-tar to prevent the corroding effects of the sea-water.

Three dynamometers were made in all; but one of them was carried away in a heavy storm the day after it was set up.

Some eighty-five readings (generally daily ones) have been obtained with the other two dynamometers, and in no case has there been any trouble in obtaining a clear and accurate measure of the maximum compression between readings.

The limits of the appreciable effects of direct wave-action during the progress of the work were 2 feet above mean low water and 10 feet above mean low water.

At the lower limit riprap, varying in weight from 40 to 150 pounds, was moved several feet in the direction of wave motion. As none of the exposed part of the work extended to the height of 10 feet above mean low water, no effects can be stated for this limit, which was that of the crest of the highest observed breakers. For comparison, however, it may be stated that an isolated piece of concrete weighing about 350 pounds and resting on its flat base 1.7 square feet in area, with its center of gravity 7 feet above mean low water, was moved several feet by breakers whose crests were about 7.5 above mean low water. These last breakers were about 3½ feet in height from hollow to crest; the others about 6 feet in height. The most constant effect of the breakers was experienced near the level of the crest of the work, 6 feet above mean low water; but undoubtedly the maximum effect would have been felt at an elevation considerably greater. All that portion of a mound or wing, composed of riprap (varying in weight from 40 to 280 pounds) tightly chinked with oyster shells, lying between 4 and 6 feet above mean low water (no matter what side slope the riprap was given) would be carried away in a single tide whenever breakers greater than 4 feet in height struck it fairly. In one case a block of concrete weighing 527 pounds was elevated 1.3 feet by the action of a single breaker. During the same tide it was moved 23 feet inshore. A dynamometer within 8 feet of its original position recorded a maximum pressure of 575 pounds per square foot during this tide.

The dynamometer readings during the month of May at the outer end of groin No. 3 have varied between 190 pounds and 753 pounds pressure per square foot.

The observed action of the breakers was of two kinds, direct and indirect.

The direct action consisted (1) in a distinct blow, as when the wave broke square against the dynamometer; (2) in distinct pressure, as when the wave broke several feet in advance of the dynamometer and the forward rush of its waters compressed the springs; (3) in a combination of these two, as when one wave would break against it and be instantly followed by the rush of water from a larger wave; (4) in the back-rush of the water, when some large wave broke up against the groin or its wings, this last being opposite in direction to the others and its effects less than those produced in the first or third cases.

The indirect action consisted only of pressure transmitted either by air or by water or by the two combined. This indirect action was shown very clearly in one case where a piece of concrete weighing 200 pounds was lifted vertically to a higher level than that of the water-surface by a wave which broke just in front of it. In another case a board about 1 foot higher than the level of the water-surface was ripped off one of the concrete blocks, when a wave broke just at the base of the boxing.

Although exposed to this severe action of sand-charged breakers, only two blocks of concrete have shown any signs of wearing away. One is a block of Portland concrete made with beach gravel (the coquina gravel having given out) containing an excess of sand. The other is the outer one of the regular Rosendale blocks, which was uncovered three weeks after being made. This wearing has made no progress during the last month.

Experience showed that the Rosendale concrete when uncovered could withstand wave action in from three to four weeks, and the Portland concrete in from two to three days.

The outer block on groin No. 3 (Portland concrete), sixty-five hours after being made, had its boxing partly destroyed by waves, exposing 92 square feet of surface. None of this concrete was washed away, although a dynamometer touching the block recorded a pressure of 509 pounds per square foot. At this time, as shown by the tests of briquettes from the same batch, its tensile strength was about 29 pounds per square inch.

This accorded fairly closely with the investigations made during the construction of the Cherbourg Breakwater, which showed that the cohesive strength required in a mortar to withstand the battering action of the waves should be at least 22¾ pounds per square inch.

I am much indebted to Mr. J. L. Brownlee, superintendent, and Messrs. E. H. Hopkins and J. S. Houston, foremen, for the great interest and efficiency displayed at all times during the prosecution of the work.

Respectfully submitted.

D. D. GAILLARD,
First Lieut. of Engineers.

Capt. W. M. BLACK,
Corps of Engineers, U. S. Army.

SPECIAL REPORT ON CONDITION OF WORKS AT NORTH POINT, ON ANASTASIA ISLAND, AND IN ST. AUGUSTINE HARBOR, FLORIDA.

UNITED STATES ENGINEER OFFICE,
St. Augustine, Fla., May 24, 1890.

GENERAL: I have the honor to submit the following report on the present condition of the work at North Point and on Anastasia Island and in the harbor of St. Augustine, Fla., as directed in Department indorsement dated May 19, 1890.

On recommendation of the Board of Engineers, approved by yourself and the Secretary of War, it was directed that the $35,000 appropriated in the act of August 11, 1888, "be applied towards checking the rapid caving in progress on Anastasia Island and on North Point" * * * "in order to prevent the threatened deterioration of the present entrance to the harbor."

Between 1791 and 1887 the total erosion of the east side of the North Point varied from 350 to 1,000 feet, the maximum erosion being near the point. On the east side of Anastasia Island the eroded portion varied in width from 850 to 2,750 feet, the maximum erosion being at a point southeast from the light-house. Between 1887 and the time the works were started (January, 1890, for North Point, and October, 1889, for Anastasia Island) the North Point high-water line had moved west about 95 feet and the point had been shortened 330 feet. On Anastasia Island the high-water line had moved west from 10 to 160 feet. The erosion was continued with every gale.

To understand the danger to the harbor threatened by this erosion it must be remembered that the ship-channel across the bar is kept open exclusively by the ebb currents from the harbor; that these currents, coming south from the North River and north from the Matanzas, are almost directly opposed within the mouth of the harbor, but at the entrance are joined together and given definite direction by the shores of North Point and Anastasia Island. It is mainly due to the relative position of these guiding shores that this entrance is so superior to that at Mosquito Inlet and the Indian River entrances.

When the North Point work began the point had already been cut back so far and the entrance widened so much that the ebb currents through the swash-channel around the point were visibly greatly increased in velocity and volume, the swash-channel was deepened and the main ship-channel was shoaler than for many years.

The appropriation is now about exhausted and work will cease in a short time. One groin has been built on Anastasia Island near the north end of the light-house reservation. This has stopped the erosion and has built out the high and low water lines for a distance of 1,560

feet to the north and south. On the North Point the main groin is located as near the extremity as was consistent with safety against being cut out by storms, and a smaller groin is built on the point. The main groin has been completed to its present length since April 14, 1890, and the groin on the point is still under construction. Already the erosion has been stopped and the low-water line beginning at a point 2,000 feet north of the groin and extending around the point has been pushed seaward a distance varying from 50 to 250 feet, as shown on the accompanying chart. The ebb currents through the swash-channel have been markedly decreased. Owing to the limited sum available, the work is of somewhat lighter character than is desirable for the exposure, but it is believed that to the extent it has gone the improvement is permanent.

From the experience already gained it is my opinion that to complete the protection the groin on the point should be extended 150 feet, a third groin should be built on the north point about 1,000 feet south of the main groin, and one should be located on Anastasia Island, directly opposite to the point, with such light intermediate works as experience may show to be necessary. The estimated cost of the additional work is $30,000.

Very respectfully, your obedient servant,

W. M. BLACK,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

P 4.

IMPROVEMENT OF NORTHWEST ENTRANCE, KEY WEST HARBOR, FLORIDA.

The Florida Keys consist of a chain of rock and sand islands extending southwesterly from Cape Florida for nearly 200 miles. They are connected by extensive sand flats, underlaid by rock, a soft oolitic limestone, from which the sand is almost entirely formed.

This chain is a barrier for all shipping from the Atlantic to the Gulf (eastern and middle) ports, and the straits between it and the West India islands form a passage justly dreaded by mariners. This barrier is crossed by four navigable channels, one between the Dry Tortugas, at the western extremity of the chain and Rebecca Shoals; one east of Rebecca Shoals; the third (the Boca Grande Channel) 28 miles further east, and the fourth (the northwest channel from Key West Harbor) immediately west of Key West, 85 miles east from the Dry Tortugas. It is this easterly position, combined with the good harbor of Key West at its extremity, which gives this channel its importance. It is used by vessels en route between the Atlantic and Gulf ports, which do not draw more than 10.5 feet of water, the depth available on the bar which now obstructs its northern end. An average daily tonnage of (estimated) 2,500 tons passes through it. In rough weather the available depth is still more reduced, and vessels of more than 8 feet draught are compelled to pass through one of the channels near Tortugas, the Boca Grande Channel being also impassable at such times.

The necessity for the improvement of the channel over this bar was first brought to the notice of Congress in 1868. An examination of the

bar was ordered by Congress. This was made by Lieut. (now Major) W. R. Livermore, Corps of Engineers, under the direction of Col. J. H. Simpson, Corps of Engineers. A project was submitted for opening a dredged channel across the bar 300 feet wide, 18 feet deep at mean low water, and 9,000 feet long, at an estimated cost of $217,272.

Nothing more seems to have been done at that time.

In 1881 another examination of the harbor was ordered by Congress. This was made by Thomas L. Harrison, assistant engineer, under the direction of Capt. (now Major) A. N. Damrell, Corps of Engineers, as reported on page 1314, Report of the Chief of Engineers, 1882. Major Damrell submitted a project for dredging a cut 300 feet wide and 17 feet deep at mean low water at an estimated cost of $140,000. In 1882 Congress appropriated $25,000 for work under this project. With this, a cut 60 feet wide and 15 feet deep at mean low water was made across the bar in 1883. In his report submitted August 12, 1884, Major Damrell states: "Unofficial reports as to the filling up of the dredged channel confirmed the opinion expressed in my last annual report, namely, that the improvement would not be permanent. No appropriation is asked for, at least until a further examination can be made." In his report submitted July 20, 1885, the officer then in charge, Capt. William T. Rossell, Corps of Engineers, confirms the report as to the filling up of the dredged channel, and asks that "an appropriation of $3,000 be made for an examination before more work is attempted." In August, 1886, Congress appropriated $2,500 for examination and survey of the entrance to harbor at Key West, Fla. This survey was made in December, 1886, and January and February, 1887, as reported in Appendix O 4, Report of the Chief of Engineers, 1887. The project submitted provided for the formation and maintenance of a channel across the bar 17 feet deep at mean low water by means of a dike along its western side, with the removal of a ledge of rocks and dredging, should that be necessary, at an aggregate estimate cost of $608,000.

An appropriation of $25,000 was made in the river and harbor act of August 11, 1888, for "Improving entrance to harbor at Key West, Fla.," with the following provision:

> The Secretary of War is authorized and directed to appoint a board of three engineer officers of the United States Army, whose duty it shall be to examine into the expediency of further improving the entrance to the harbor at Key West, Florida, upon the plan submitted by Lieutenant William M. Black, United States Army Engineers, under date of May 31, 1887; the said Board shall report to the Secretary of War, who shall lay its report before Congress at its next session, together with the views of himself and the Chief of Engineers of the United States Army thereon.

In accordance therewith a Board of Engineer Officers, consisting of Col. Henry L. Abbot, brevet brigadier-general, U. S. Army; Lieut. Col. Peter C. Hains, and Capt. W. H. Bixby was constituted by Special Orders No. 60, Headquarters Corps of Engineers, U. S. Army, November 2, 1888, and directed "to assemble * * * at Key West, Fla., * * * upon the call of the senior member, and as soon as the other duties of the members and the sanitary condition of Florida will permit to examine into and report upon the plans * * * for the further improvement of the harbor." * * *

The Board met at Key West on January 22, 1889, and made a personal examination of the harbor and bar. Their report was printed as a part of Ex. Doc. No. 145, House of Representatives, Fiftieth Congress, second session, and is given with the annual report for 1889.

After stating that "the improvement of the Northwest Channel Passage is emphatically a work of national importance," that "the natural forces available for the improvement are ample," and that the "pro-

posed general method, namely, training work, supplemented, if necessary, by dredging, promises success at a cost quite within reasonable limits," the Board requested certain additional information, which could not be obtained with the limited funds available for the original survey.

On April 6, field work for obtaining the necessary data was started, by authority from the Chief of Engineers, and was continued until June 3, 1889. It was resumed September 23, and finished September 30, 1889. Current observations were made at ten stations simultaneously in sets of six in the Northwest Channel and its vicinity for current velocities and directions during flood and ebb tides. One hundred and twenty-seven borings were made and 274 miles of soundings were run. For the details of the methods employed, attention is invited to the reports of Mr. J. W. Sackett, assistant engineer, printed with the annual report for 1889. The data obtained by this survey was forwarded to the Board by the officer in charge with a letter dated September 30, 1889. The Board reassembled in New York, October 23, 1889, and submitted a report dated November 2, 1889. This was transmitted to Congress by the Hon. Secretary of War December 5, 1889, accompanied by a letter from the Chief of Engineers dated December 3, 1889. All of the papers and maps appeared in Ex. Doc. No. 39, House of Representatives, Fifty-first Congress, first session, printed herewith.

The Harbor at Key West is in the collection district of Key West, Fla., which is the nearest port of entry. Nearest light-house, Northwest Passage Light. Nearest fort is Fort Taylor, Fla.

Money statement.

July 1, 1889, amount available	$19,028.33
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	1,936.69
July 1, 1890, balance available	17,091.63
Amount appropriated by act of September 19, 1890	40,000.00
Amount available for fiscal year ending June 30, 1891	57,091.63
Amount (estimated) required for completion of existing project	460,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	460,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

COMMERCIAL STATISTICS.

Commerce of Key West, Florida, during the year ending December 31, 1889.

[Compiled by Mr. George Phillips, Key West, Fla.]

EXPORTS.

Article.		Quantity.	Estimated value.
Cigars	number	94,000,000	(*)
Sponges	pounds	414,345	$1,035,233.53
Pine-apples	dozen	330,461	216,420.30
Vegetables	crates	239,329	633,987.00
Green turtle	pounds	72,000	3,600.00
Hides	number	15,000	18,000.00
Fish, fresh	pounds	792,000	25,583.00
Fertilizers	tons	200	4,000.00

* Not obtainable.

Commerce of Key West, Florida, during the year ending December 31, 1889—Continued.

IMPORTS.

Article.		Quantity.	Estimated value.
Vegetables		.....	11,584.00
Fruits		.....	29,809.00
Fish, salt	pounds..	51,930	4,070.00
Beef cattle	number..	580	7,428.00
Horses	do...	186	1,879.00
Hogs	do....	190	547.00
Sheep	do ..	56	59.00
Wines	gallons..	15,609	4,591.00
Gin	do....	1,050	510.00
Lumber, sawed	feet..	3,250,000	56,875.00
Plastering laths	number..	1,600,000	16,000.00
Cypress shingles	do....	1,200,000	42,000.00
Bricks	do....	2,000,000	24,000.00
Coal	tons..	9,200	.....
Merchandise (including ship stores)	do...	1,600	.....
Tobacco	pounds..	1,673,409	778,522.50

	Number.
Passengers from foreign ports	7,601
Passengers to foreign ports	7,581
Passengers arriving and departing coastwise	9,125

AMERICAN SHIPPING.

Class of vessels.	No.	Gross tonnage.
Steamers to and from foreign and domestic ports	640	6,548.73
Sailing vessels to and from foreign ports	350	43,679.00
Sailing vessels in the fruit and sponge trades	148	1,520.00
Fishing and turtling boats	200	800.00

LETTER OF THE COLLECTOR OF CUSTOMS.

KEY WEST, FLA., *July* 12, 1890.

DEAR SIR: In response to your request of the 8th inst., I have the honor to report that the amount of customs collected at this port for the year ended December 21, 1889, was $680,625.89.

Tobacco imported was 1,673,409 pounds, valued at $778,522.50.

Very respectfully,

JOHN F. HORR,
Collector of Customs.

Capt. W. M. BLACK,
Corps of Engineers, U. S. A.

FINAL REPORT OF THE BOARD OF ENGINEERS UPON THE FURTHER IMPROVEMENT OF THE ENTRANCE TO THE HARBOR AT KEY WEST, FLORIDA.*

LETTER OF THE SECRETARY OF WAR.

WAR DEPARTMENT,
Washington City, December 5, 1889.

The Secretary of War has the honor to transmit to Congress, in compliance with the requirements of the river and harbor act of August 11, 1888, the report of the Board of Engineer Officers convened to ex-

* The preliminary report of the Board is published in the Annual Report of the Chief of Engineers for 1889, pages 1328–1337.

amine into the expediency of further improving the entrance to the harbor at Key West, Fla. The views and recommendations of the Board are concurred in by the Chief of Engineers and by this Department.

REDFIELD PROCTOR,
Secretary of War.

The SPEAKER OF THE HOUSE OF REPRESENTATIVES.

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., December 3, 1889.

SIR: I have the honor to submit herewith a copy of the final report of the Board of Engineer Officers, organized in obedience to the requirements of the river and harbor act of August 11, 1888, to examine into the expediency of further improving the entrance to the harbor at Key West, Fla., upon the plan submitted by Lieut. William M. Black (now captain), Corps of Engineers, May 31, 1887, etc.

A preliminary report of the Board was submitted to Congress February 19, 1889, and is printed in House Ex. Doc. No. 145, Fiftieth Congress, second session.

The report of the Board now submitted, dated November 2, 1889, is based upon additional information gained by Captain Black's observations, "and particularly the discovery of a buried rock channel at the entrance of the harbor, which will, in his opinion, permit the improvement of the bar to a depth greater than that contemplated in his original project of May, 1887, and at a reasonable cost." That officer "now recommends that no work should be done which would interfere with the clearing-out of this buried channel and modifies his original project accordingly. That project contemplated a depth of 17 feet at mean low tide at a cost of $600,000. His new project looks to an ultimate depth of 24 feet at mean low tide, at a cost of about $1,500,000."

The important data respecting the tidal currents resulting from the new surveys have received the most careful consideration of the Board of Engineers and have led to the following conclusions:

In its opinion it is doubtful whether a single jetty located on the west side of the channel, as suggested and located by Captain Black in his letter of May 21, 1887, would secure a depth of 17 feet at mean low tide at a cost of $600,000, as estimated by him; and, moreover, this western jetty placed in the best position to give a moderate increase of depth would not be best placed for a future extension of the improvement.

In order to accomplish the most good a single jetty should be placed on the northeastern side of the channel, where it would direct the wasted energy of the strongest overflow currents to where work is needed on the present bar channel; and such a single northeastern jetty (estimated to cost $500,000) would be more effective than a single western jetty and, moreover, must form part of any project to obtain the greatest depth (24 feet) permitted by the underlying rock formation.

Work upon the bar of the northwest passage involves so many uncertainties that the Board does not favor at present any attempt to obtain the full 24-foot depth, but it is convinced that the improvement which may be fairly expected from a northeastern jetty, as recommended below, will justify its cost, although the exact deepening in feet can not be predicted with accuracy.

The Board recommends that a stone jetty, bedded in whole or in part on rock in place, be constructed along the submerged reef on the northeast side of the northwest passage near its northerly end.

After this northeastern jetty is constructed, and from its effects, a better judgment than is now possible can be formed as to what further work is expedient. * * *

A second jetty on the west side of the bar channel, as recommended by Captain Black, may become necessary after the one on the easterly side is constructed. * * *

It may become desirable to supplement jetties by dredging and the project contemplates such work.

The estimated cost of the construction of the northeastern jetty above recommended is about $500,000. That this expenditure will materially improve navigation over the worst portion of the existing bar channel, and will indicate the direction and extent to which further works may profitably be carried, can hardly be doubted.

Further than this, in a work of so novel a character, no prediction can safely be made.

The Board can not too strongly express its conviction that, if Congress decides to inaugurate this work, its success should be regarded as dependent upon liberal appropriations. To attempt to modify conditions resulting from the action of powerful and continuous natural forces by feeble and intermittent efforts, is always of doubtful utility; and in the northwest passage, where the work is far from land and where the liability of being outflanked is so great, such a financial system foredooms the work to failure.

The views and recommendations of the Board are concurred in by me.

Either the project should not be undertaken or $500,000 should be provided from the start.

The report is accompanied by numerous maps and drawings and also by a relief map* in plaster of paris, showing the bar obstructing the entrance to the northwest channel, prepared under the direction of Captain Black.

Very respectfully, your obedient servant,

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

Hon. REDFIELD PROCTOR,
Secretary of War.

REPORT OF THE BOARD.

NEW YORK CITY, N. Y.,
November 2, 1889.

GENERAL: The Board of Engineers constituted by the river and harbor act of August 11, 1888, and Special Orders, No. 60, Headquarters Corps of Engineers, dated November 2, 1888, and September 2, 1889, has the honor to submit the following report upon the entrance to the harbor of Key West, Fla.:

The views of the Board as to the national character of the improvement of the northwest passage, its commercial and military importance, its general engineering features, and its feasibility, were fully stated in its preliminary report dated January 31, 1889, already printed in House Ex. Doc. No. 145, Fiftieth Congress, second session, to which attention is invited.

Pursuant to order, the Board reconvened at New York City on the 23d of October, 1889.

In accordance with its suggestions at its previous meetings, Captain Black submitted the following new data:

First. Results of simultaneous velocity observations taken under normal conditions of wind and weather at all stages of the tide, at ten new stations in the vicinity of the bar.

Second. Results of corresponding tidal observations at the northwest light.

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* Not submitted.

Third. Results of borings showing the character of the bottom to bed-rock on and in the vicinity of the bar.

Fourth. A special relief map of the northwest passage and its vicinity, by the use of which the study of the problem was greatly facilitated.

Captain Black also presented a report, with maps, discussing the physical significance of the above data, together with a new project and increased estimates.

The increased knowledge of the problem gained by these additional observations, and particularly the discovery of a buried rock channel at the entrance will, in Captain Black's opinion, permit the improvement of this bar to a depth greater than that contemplated in his original project of May, 1887, and at a reasonable cost. That officer now recommends that no work should be done which would interfere with the clearing out of this buried channel, and modifies his original project accordingly. That project contemplated a depth of 17 feet at mean low tide, at a cost of $600,000. His new project looks to an ultimate depth of 24 feet at mean low tide, at a cost of about $1,500,000.

The new surveys confirm the discovery announced by Captain Black in his first report that the existence of the bar is due to the conflict between two tidal currents, one flowing nearly north and south through the northwest passage, and the other nearly east and west along the northern side of the general reef. It also makes known the important fact that the whole sandy bar is underlaid by rock in place at no great depth below the surface, and that there is, nearly in prolongation of the existing northwest passage, a natural ravine now filled with sand across this reef, having a width of about 1,000 feet near the bar and a least depth at mean low tide of 24 feet, the tidal oscillation being about three feet. The significance of this new discovery and its bearing upon the projected works of improvement are evident without comment.

The new data, however, also prove that the indications of the preliminary surveys, as to the flood-currents in the northwest passage largely predominating over the ebb, apply only when the tidal range from low to high water exceeds that from high to low water, as is often the case; *i. e.*, this predominance only holds good when the tidal conditions existing during the measurements made in November, 1888, obtain. The evidence now in possession of the Board establishes that in general no such predominance can be assumed, and hence that great caution is necessary, in carrying out any system of improvement, to avoid the formation of deposits in the existing deep channel. The rock contours under the bar also make it apparent that there must be no undue contraction of the water-way in attempting to remove deposits in and toward the deep ravine above mentioned.

The current observations of May 10 and 11, 1889, were made when the tidal curves at the light-house prove that the normal conditions obtaining in favorable weather existed; and the fact that no marked changes in the position of the best passage over the existing bar are noted after strong northwest gales, warrants the assumption that these conditions may be accepted as governing in this vicinity.

A very careful study of the data for these two days (which are confirmed by all the known facts observed) has therefore been made by the Board, greatly assisted by the admirable relief map prepared by Captain Black. His plate No. 2 affords every facility for such a study, exhibiting, as it does, the strength and direction of the currents at all his velocity stations at each of the ten equal tidal stages in the northwest

passage during flood, and at the ten corresponding tidal stages during ebb. The following results have been thus reached ;

NORTHWEST CHANNEL AT KEY WEST.

Beginning at flood stage No. 1 (gauge-reading at light-house 0.2 foot ; the zero being at mean low water).—All velocities are a half a foot per second or less. Current sweeps up Northwest Channel and round the light house to the southwest. An east jetty would check a strong outflow in its southern portion, but not at its northern. A west jetty would effect a desirable change of direction and prevent conflict of tidal currents.

Flood stage No. 2 (gauge reading zero).—Little change in any of the directions of flow, or in the velocities except in the Northwest Channel and east group, where they are nearly doubled. The east group currents all flow to the north. An east jetty would now be very effective, and a west jetty moderately so. Combined they would act vigorously.

Flood stage No. 3 (gauge reading minus 0.1 foot).—Velocities in Northwest Channel and on bar have largely increased, as have also those in the east group. Those in the west group have diminished. An east jetty would do excellent work ; a west jetty alone would have little effect.

Flood stage No. 4 (gauge reading zero).—Gulf currents nil. Velocities in Northwest Channel and east group have increased nearly to the maximum, *i. e.*, to 2.4 feet and about 1.7 feet. The flow is nearly at its minimum at west group. An east jetty would be very effective ; a west jetty, nil.

Flood stage No. 5 (gauge reading 0.2 foot).—Directions and velocities in Northwest Channel and in east group unchanged. Gulf tide begins to flow eastward. Velocities in west group are very feeble, and in east group very effective. An east jetty would have great effect, and a west jetty, nil.

Flood stage No. 6 (gauge reading 0.6 foot).—Current in Northwest Channel unchanged ; the same is true in east group as to direction, but the flow is rather less. The west group show feeble action, in direction toward northeast. An east jetty would be effective, and a west jetty, nil.

Flood stage No. 7 (gauge reading 1.0 foot).—The Northwest Channel and east group show a slight decrease of velocity, with directions unchanged. Velocity in west group slightly increasing. That in Gulf is increasing (*i. e* , to 0.7 or 0.8 foot). An east jetty would be effective; a west jetty would simply prevent conflict of tidal currents.

Flood stage No. 8 (gauge reading 1.4 feet).—The Northwest Channel and east group currents show slight deflection to eastward, and are less strong (being 1.5 feet and about 1.0 to 0.6 foot). The Gulf current is rather increasing (0.8 foot). The west group are slightly increasing. An east jetty would be effective, but a west jetty would prevent conflict of the currents. With two jetties combined this would be an important advantage.

Flood stage No. 9 (gauge reading 1.8 feet).—All currents remain unchanged in direction, except that the Gulf flow near the eastern group is more sensible to the eastward. The absolute velocity at all the stations show less differences than before. An east jetty would still be effective ; a west jetty would be useful for preventing conflict of currents.

Flood stage No. 10 (gauge reading 2.1 feet).—No velocity of importance anywhere. In the Northwest Passage the velocity is 0.35 foot, and at the west group 0.5 foot. No jetty would be effective. The current in Northwest Channel is at the slack.

Ebb stage No. 1 (gauge reading 2.3 feet).—Currents at all stations change greatly in direction, except in the Gulf where the flow is still eastward with a velocity of 0.67 foot per second. In Northwest Channel there is a decided southeast current (0.7 foot to 0.8 foot). It is now slackwater on the bar channel. A feeble inflow begins from all directions toward the Northwest Channel. No jetty would be of service.

Ebb stage No. 2 (gauge reading 2.6 feet).—Strong current (1.6 feet per second) down the Northwest Passage and over the southern two-thirds of the east group. All flow is toward the Northwest Passage, but the westerly group show feeble velocities. This is particularly true over the bar channel. The east jetty would exclude much water and increase the flow over the bar channel. The effect of a westerly jetty would be nil.

Ebb stage No. 3 (gauge reading 2.8 feet).—The currents in the Northwest Passage are very strong (2.15 feet per second). The east group all show a powerful flow toward the Northwest Passage (1.2 to 1.6 feet per second); all other currents are feeble and ineffective. The tide along the reef is now at its high-water slack. The east jetty would now exclude water and thus tend to increase the flow over the present bar channel. The effect of the west jetty would be nil.

Ebb stage No. 4 (gauge reading 2.7 feet).—The Northwest Passage shows velocity of 2.3 feet, and the east group velocities ranging from 1.6 feet to 0.9 foot per second to the southward; the west group currents are feeble and tend toward the west, as does the flow along the reef. There is an evident suction toward the Northwest Passage near the bar channel. An east jetty would exclude very much water; but the flow thus caused, while tending to increase the current down the passage, might also increase the scour beyond its southern end. The west jetty would act favorably.

Ebb stage No. 5 (gauge reading 2.5 feet).—The Northwest Passage now has its maximum flow toward Key West (2.5 feet per second), the east group ranging from 0.9 foot to 1.4 feet per second toward the passage. The west group all tend westward (0.5 foot to 0.7 foot per second). An east jetty would exclude much water. A west jetty would throw water down the passage and thus be of service.

Ebb stage No. 6 (gauge reading 2.2 feet).—The currents of the Northwest Passage and east group are unchanged in direction and force. The flow at the west group and in the Gulf is now nearly parallel to the reef, moving westward and has about its maximum velocity (0.5 to 0.8 foot per second). The action of jetties would be as at the last stage.

Ebb stage No. 7 (gauge reading 1.8 feet).—In the Northwest Passage the southerly current is still strong, and the east group show velocities of about a foot per second, converging to it. On the bar channel and in the west group the flow is westwardly and parallel to the reef, with velocities of about 0.7 foot per second. The effect of an east jetty would be to increase the tendency of scour southward of it, the two currents in the passage and along the reef being at right angles to each other. A west jetty would do good work.

Ebb stage No. 8 (gauge reading 1.4 feet).—No change in direction of flow from the last stage. The east group indicates a slackening of the

flow, but the west group is unchanged in this respect. The effect of jetties would remain as at the last stage, but would be more pronounced.

Ebb stage No. 9 (gauge reading 1.0 foot).—No change in direction of flow, but a general falling off of velocity, This is now 1.22 feet per second in the passage, and 0.7 foot in the east group. In the west group it is about 0.75 foot, as before. The action of jetties would remain unchanged.

Ebb stage No. 10 (gauge reading 0.5 foot).—The direction of flow remains unchanged, but the velocities are all ineffective, except in the west group, where they range from 0.8 to 0.6 foot per second. No jetty would be of utility.

The observation of Mr. Sackett, quoted by Captain Black, that currents at no time exceeding 1.5 feet per second cause a rapid movement of the sand, of which the bar is composed, is of great value in estimating the probable action of contraction works in this vicinity.

After a careful study of these data and all other available facts, the Board has reached the following conclusions:

In its opinion it is doubtful whether a single jetty located on the west side of the channel, as suggested and located by Captain Black in his letter of May 31, 1887, would secure a depth of 17 feet at mean low tide at a cost of $600,000, as estimated by him; and, moreover, this western jetty, placed in the best position to give a moderate increase of depth, would not be best placed for a future extension of the improvement. In order to accomplish the most good a single jetty should be placed on the northeastern side of the channel, where it would direct the wasted energy of the strongest overflow currents to where work is needed on the present bar channel; and such a single northeastern jetty (estimated to cost $500,000) would be more effective than a single western jetty, and, moreover, must form part of any project to obtain the greatest depth (24 feet) permitted by the underlying rock formation.

Work upon the bar of the Northwest Passage involves so many uncertainties, that the Board does not favor at present any attempt to obtain the full 24-foot depth; but it is convinced that the improvement which may fairly be expected from a northeastern jetty, as recommended below, will justify its cost, although the exact deepening in feet can not be predicted with accuracy.

RECOMMENDATIONS.

The Board recommends that a stone jetty, bedded in whole or in part on rock in place, be constructed along the submerged reef on the northeast side of the Northwest Passage near its northerly end. This jetty should extend from near velocity station 10, northwesterly to a distance of about 1,500 to 2,000 feet, and southeasterly to a point about midway between velocity stations 8 and 7, where the general surface of the rock is about 10 feet below the level of mean tide, care being taken not to encroach too much on the channel. The work should begin with the bottom layer of stone, 4 or 5 feet thick, over the entire length. The northwest portion should then be raised approximately to the level of mean low water, and the construction should proceed southerly, modifying the height according to the effects produced. This jetty would not interfere with the existing channel, and would form a necessary part of any project for obtaining the maximum depth permitted by the underlying rock.

After this northeastern jetty is constructed, and from its effects a

better judgment than is now possible can be formed as to what further work is expedient, possibly it may be desirable to extend the jetty farther to the southeast, the best location being determined by the depth and position of the rock in place, a matter concerning which precise information is lacking at present.

A second jetty on the west side of the bar channel, as recommended by Captain Black, may become necessary after the one on the easterly side is constructed, but neither the exact location nor length can be determined until after the effects of the first are observed. Such a jetty might afford some protection from northwesterly gales and from heavy seas rolling in from that direction, and would prevent injurious conflict of the two tidal currents during the latter third of the flood and injurious cross currents during the latter half of the ebb.

It may become desirable to supplement jetties by dredging, and the project contemplates such work.

The estimated cost of the construction of the northeastern jetty above recommended is about $500,000. That this expenditure will materially improve navigation over the worst portion of the existing bar channel, and will indicate the direction and extent to which further works may profitable be carried, can hardly be doubted. Further than this, in a work of so novel a character, no prediction can safely be made.

If it should become necessary in the progress of the work to extend the jetty southward, an additional expenditure roughly estimated at $200,000 would probably be required. If in addition to this a western jetty raised 4 feet above low water and capped should be ultimately demanded, its cost, according to Captain Black's figures, would be about $900,000. But such extensions of the project now recommended should, in the opinion of the Board, await further developments.

The Board can not too strongly express its conviction that if Congress decides to inaugurate this work, its success should be regarded as dependent on liberal appropriations. To attempt to modify conditions resulting from the action of powerful and continuous natural forces by feeble and intermittent efforts, is always of doubtful utility; and in the Northwest Passage, where the work is far from land, and where the liability of being outflanked is so great, such a financial system foredooms the work to failure. Either the project should not be undertaken or as much money as can be economically expended should be provided from the start.

The following papers accompany this report:

Report of Captain Black dated September 30, 1889, giving the results of the new surveys; and transmitting a report of his assistant, Mr. J. W. Sackett, dated June 24, 1889* upon the methods employed in taking the current observations and making the borings and soundings; also, report of Mr. Sackett, dated September 20, 1889, upon the survey of northwest entrance to Key West Harbor.

Also the following: †

Table showing classification of sand borings.

Plate 1, in 3 sheets, map of Northwest Channel.

Plate 2, table of tidal and current data.

Plate 3, in 2 sheets, curves of current velocities and of tides.

Plate 4, diagrams of current velocities and directions.

Plate 5, in 4 sheets, current velocities and directions at stations.

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*Published in Annual Report of the Chief of Engineers for 1889, pages 1326–1328.

† Omitted; published in House Ex. Doc. No. 39, Fifty-first Congress, first session.

Also a relief map showing the bar obstructing the entrance of the Northwest Channel.

Respectfully submitted.

HENRY L. ABBOT,
Colonel of Engineers,
Bvt. Brig. Gen., U. S. A.
PETER C. HAINS,
Lieut. Colonel of Engineers.
W. H. BIXBY,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF CAPTAIN WILLIAM M. BLACK, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
St. Augustine, Fla., September, 30, 1889.

GENERAL: I have the honor to submit the following report on the results of the further examinations of the northwest entrance to the harbor at Key West, Fla., made in accordance with Department indorsement of February 16, 1889, on recommendation of the Board of which you are president.

The information desired consists, "(1) of simultaneous velocity observations taken under normal conditions of wind and weather at all stages of the tide, at ten stations indicated in the accompanying copy of the map of Captain Black's survey, (2) of corresponding tidal observations at the northwest light, and (3) of borings along the lines indicated on the map, to determine the character of the bottom to a depth of at least 20 feet below mean low water and extending, if practicable, to bed-rock."

In addition to this you desired any further information which might throw light on the problem under any new conditions developed during the survey.

The field work was again under the charge of Mr. J. W. Sackett, assistant engineer. To his able and interested aid I am greatly indebted. Before the work could be completed the summer was well advanced at Key West, and Mr. Sackett and his party were subjected to all the discomforts incident thereto. On several days work had to be carried on during fifteen consecutive hours in order to secure the observations required. As the work advanced, it became evident that the earlier survey of the area to the northeast of the channel was not sufficiently full, and, as in these shifting sands slight changes are of constant occurrence, it was deemed best to make the entire survey again, extending the area covered farther to the east and to the west.

The present map thus shows the sand contours at the time when the bulk of the current observations were made. Except in covering a greater area in greater detail, it differs in no essential particulars from the map of 1886–1887.

For details of methods I would invite attention to the accompanying reports of Mr. Sackett, dated June 24 and September 20, 1889.

The information derived from this survey may be summarized under three heads, (1) the direct influence which the range of the tide at the Northwest Light has on the direction of the effective resultant velocity for any one entire tide, (2) the difference in the direction of flow of the tidal currents on the reef east and west of the bar, (3) the stability of the location of the Northwest Channel as shown by the rock contours.

Tidal range and current velocities.—As seen from the tidal curve, at spring tides, for two successive entire tides, the difference in range during ebbs is much greater than the difference during floods, or, in other words, the water falls on one short and one long ebb, but rises by two more nearly equal floods. From this it follows that sometimes, for one entire tide, the effective resultant is with the ebb, at others with the fload currents.

The observations of November 26 and November 30, 1888, showed greater velocities for the flood currents, those of April 16 and 17, 23 and 24, 1889, greater velocities for the ebbs, those of May 2 and 3 the same, and in those for May 10 and 11 the velocities are nearly equal.

Current velocities and directions.—Observations for current velocities and directions were made at the ten stations indicated. Their locations are shown on the map (Plate 1). Station 1 was located at a point in the Northwest Channel where the ebb and flood currents were opposite in direction and parallel to the channel; station 6

was in the channel opposite the Northwest Light; stations 7, 8, 9, and 10 were in the area on the reef north and east of the Northwest Channel; stations 11, 12, and 13 on the reef to the west of the Bar Channel; station 14 was in the deep water north of the reef sufficiently distant from the bar to be comparatively free from the influence of the Northwest Channel currents. A tide-gauge was read at the Northwest Light, night and day, during the entire survey. As it was not practicable to make the observations simultaneously at the ten stations, six stations were occupied during each day's work. This permitted observations to be taken at stations 1 and 10 in every set. Any abnormal tidal movement can thus be discovered when the sets are compared. Three complete sets of observations, covering entire ebb and flood tides were taken. Finally, as detailed in Mr. Sackett's report, on May 10 and 11 entire tides were observed each day under conditions which are believed to be normal. Plates 2, 3, 4, and 5 show the tabulated results of these observations. For purposes of comparison the observations of November 26 and 30, 1888, at stations 2′ 3, and 5 are also given. In all cases, excepting for some observations of ebb currents at station 2′, the velocities and directions are those obtained by the use of the float-rods, and therefore represent the means. In the excepted case there was a strong wind prevailing, which gave misleading results. In this case the velocities and directions are those obtained by the use of the double float. Where all the velocities are combined for comparison, the observations of May 11 are used for stations 1 and 10.

On Plate 3 are plotted the tidal curve at the Northwest Light from April 8 to June 14, and on a larger scale, the curve for May 10 and 11, from observations taken. A regular tidal curve for Fort Taylor is also shown plotted from the tidal constants given in the tide tables of the United States Coast and Geodetic Survey. In the absence of exact information, the mid-tide at the two points is assumed to be at the same level, though, as stated by Mr. Sackett, it is not at all certain that such is the case.

For convenience the ebb and flow velocity curves for station 1 in Plate 3 are divided into ten parts of equal duration in time. The mid velocity of each of these parts or stages is used in the diagrams of Plates 4 and 5 for comparison with the velocities of the other stations at the same hours.

Analysis of current observations.—An inspection of Plates 3, 4, and 5 shows that the currents at station 14 correspond very closely with the tidal changes at the Northwest Light. Slack water at station 1 occurred from forty to fifty-five minutes later than the predicted time for high and low water at Fort Taylor. During the survey, casual observations of the shipping at Key West showed slack water in the harbor there about twenty minutes earlier than it occurred at station 1. The changes at station 1 were from one to two hours earlier than those at the Northwest Light. Hence it is evident, as is shown also by the current observations themselves, that the currents on the bar are the effects of the resultants of two distinct sets of forces, those represented by the Northwest Channel currents and those represented by the tidal curve at the Northwest Light and the currents north of the reef.

In Plate 5 the stations are plotted in their proper relative positions on the same scale as in Plate 1. Sheets 1 and 2 show the velocities and directions during ebb and flood, respectively, at station 1, the figures in their order, 1 to 10, referring to the various stages, as before explained. Sheets 3 and 4 show the velocities and directions during ebb and flood stages at station 14; the figures refer to the same stages as in sheets 1 and 2, but are now in the order 4, 5, 6, 7, 8, 9, 10, 1, 2, 3, from beginning to end of flood.

An examination of these sheets shows that the maximum current velocities on the bar are evidently due to the flood currents of the Northwest Channel, and that the channel across the bar is kept open by them. In considering a project for improving this channel, therefore, all of the currents will be grouped and examined with reference to the stages of the Northwest Channel currents.

The changes of one complete tide may now be examined.

Beginning at high-water stand, the tide is running flood north of the reef with nearly a maximum velocity. The ebb currents start toward the Northwest Channel in all directions from the north face of the reef, though with the greatest velocity past the stations to the east of the Bar Channel. This continues until the fourth stage, through one hundred and fifteen minutes, or three-tenths of the ebb.

The tide at the Northwest Light now (at the fourth stage) begins to fall and the currents north of the reef to run to the west. The currents on the bar and west of the Bar Channel follow this direction. The currents in the Northwest Channel, fed through the area east of the Bar Channel, continue to increase until the maximum velocity is attained at the fifth stage, and then decrease in velocity slowly. At the ninth stage the currents north of the reef have attained a maximum velocity, the tide has fallen through more than one-half its range, and the velocities of the group east of the Bar Channel and in the Northwest Channel have diminished to one-half of their maximum velocities. This period has lasted for two hundred and thirty-one minutes. or six-tenths of the ebb.

During the remaining ebb stage the currents north of the reef continue constant in velocity and direction, those in the areas east and west of the Bar Channel conform in direction to them, though with diminished velocities in the east group, and the currents in the Northwest Channel decrease to zero.

At low-water slack of station 1 the rate of fall of the tide at the light has diminished. The currents north of the reef and in the west group have diminished in velocity and have begun to swing to the north. The currents of the east group, which became slack slightly before this time, have begun to flow to the north, inclining to the northwest as the northern side of the reef is approached. During stages 1 and 2 these conditions continue. At stage 3 the tide is at its lowest point. At stage 4 the velocities north of the reef are at a minimum and the currents have swung to the north. The bar current is a maximum. The directions in the east group and on the bar are along the shortest lines from deep water to deep water. During stages 1, 2, 3, and 4 the velocities at stations 11 and 12 remain large, fed from the Northwest Channel. These stages last for one hundred and forty-six minutes, four-tenths of the flood.

At stage 5 the maximum current is found at station 1. The currents north of the reef are running flood with two-tenths of the velocity at station 1, and in direction form an angle of 96 degrees with them. On the bar and in the east and west groups the velocities have diminished and the directions have swung slightly to the east. During stages 6, 7, 8, and 9 the velocities north of the reef and in the west group, excepting station 11, steadily increase. On the bar, in the east group and in the Northwest Channel, the velocities decrease. In the west group the directions conform more or less closely with the directions north of the reef, followed more slowly by those on the bar and in the east group.

At stage 10 the velocities have all decreased. In the east and west groups the directions conform to those of the reef.

As shown graphically in figures 61 to 73, Plate 4, the stations fall naturally into groups. Fourteen and 3, 1 and 6 may be denominated primary groups; 5, 11, 12, and 13 form a secondary group (the west group), mainly influenced by 14 and 3; 7, 8, 9, and 10 a secondary group, mainly influenced by 1 and 6. At station 2 during ebb the influence of the currents north of the reef seems the stronger, and during flood those of the Northwest Channel.

For three-tenths of the ebb the water flows toward the Northwest Channel past all stations, though with the greatest velocity past those of the east group. During the remaining time the Northwest Channel currents are fed through the east group alone.

For four-tenths of the flood the currents of the Northwest Channel spread out and flow past all of the stations. During the remainder of the flood they are met by the currents north of the reef, their power diminished and their direction turned toward the east.

Rock contours.—The rock contours show a nearly straight channel with a least mid depth of 25.4 feet, prolonging the present Northwest Channel to deep water. This channel is protected and defined on both sides by rock which rises to within 10 feet of the water surface on the east, and to within 7 feet of the water surface on the west.

Sand borings.—Where the rock is not exposed it is covered with calcareous sand, composed of fragments of shells and of the disintegrated rock. For purposes of comparison this sand may be divided into seven grades, according to the number of coarse particles it contains, numbered 1 to 7, from fine to coarse.

The accompanying table shows the distribution of the sand under this classification. It will be noted that the very fine sand is only found on the surface north of the 24-foot contour of the reef; that along the 12 and 18 foot contours the sand is generally coarse, the larger particles being at the bottom, and that in general the coarser sand is found where the large velocities were observed. In the sand-covered portion of the ancient channel the borings generally show the coarser sand at the bottom, proving the existence of large velocities there when the first deposits were made.

As stated in previous reports, when the wave motion is great the whole body of water on the reef becomes milky with the stirred-up sand. In addition to this Mr. Sackett found that at all times it is in motion.

"The water was remarkably clear during nearly the entire survey, so much so that the bottom could be discerned plainly in 3 fathoms. This incidentally led to casual observations of the appearance of the bottom, particularly at the current stations. A water glass (a large bucket with a glass bottom) was used for this purpose, and with it the grains of sand on the bottom were plainly visible. Rock bottom or 'bar' as it is locally termed, always appeared to have a growth of 'feathers,' 'fans,' and sea-weed, a kind of vegetation which I am told is always characteristic of it. Frequently it has what are called 'yellow heads,' masses of living coral, spherical in shape, supported above the general level of the bottom by a short 'neck,' generally of less diameter than the portion above. These are of all sizes up to 4 or 5 feet in diameter.

"Where the bottom is undisturbed by the currents or by wave action it is generally covered with grass. Where there is neither rock nor grass the bottom is white sand. Current stations 1 and 9 were on rock bottom. Station 6 was on grass bottom. The other stations were on white sand bottom.

"Sand waves were found at each of the stations where the sand was bare. We observed that the wave crests were at right angles to the direction of the currents. The wave length seemed to increase as the velocity of the current increased, until the maximum current velocity was attained, when the wave length in feet was about two-thirds the current velocity in feet per second. It then remained about the same until the current changed its direction, when the waves would become obliterated. In the course of about half an hour after the current had assumed a definite direction the waves were reformed correspondingly. The rate of advance seemed to be about one-fiftieth of the velocity of the current. The slope of the side toward the current was about 1 on 5; on the other side it was about 10 on 4.

"At no time during these observations did the current velocity exceed 1.5 per second." (Report of Mr. J. W. Sackett, assistant engineer.)

Stability of Northwest Channel and Bar.—The stability of the Northwest Channel bar in its present state, testified to by the charts reaching back one hundred years, gives evidence that when the now filled mouth of the rock channel was open a different condition of affairs must have obtained, for it does not seem possible that this channel could have been formed and kept open in the face of the currents now passing along the north side of the reef. Incidental evidence on this point is given in the present channel, which maintains its depth only so far as protected by the reef on its west side. The manner in which the channel depth diminishes as the rocky point beyond the light is neared from the south, the extension of the 15-foot contour close under the lee of the rock, and the correspondence of depth on the rock and beyond it are very instructive. And indeed it is not difficult to believe that these currents north of the reef are of a comparatively recent date, and that before the reef was formed to its present height the flood currents were able to sweep directly across it east of Key West, filling the basins of the gulf without a tardy progress around from the westward.

Project of improvement.—From economical considerations the position to be given an improved entrance to the Northwest Channel of any given depth must be limited by the positions of the corresponding rock contours of the ancient channel. It was these considerations which limited the depth recommended in the earlier project to 17 feet.

From the borings made by your direction, it is now evident that this 17-foot limitation does not exist, and that it is possible to gain a greater channel depth without undue cost. The commercial importance of the Northwest Channel is so great that even were the depth of 17 feet considered sufficient for present needs no project should be adopted which would not permit the expansion to a greater depth at some future time.

Twenty-four feet can now be carried from the Atlantic Ocean as far as station 6, and as far as can be learned there is no barrier of rock to prevent this depth from being prolonged to deep water north of the reef. I would respectfully submit to the Board the great desirability of providing for such a channel.

You have already approved of the general method of improvement by training-walls, assisted by dredging, if necessary. I beg to submit the following considerations concerning the location of a training-wall:

To improve the entrance the currents through it must be given sufficient velocity and volume, with a distinct effective resultant in one direction, and their direction must be parallel to its length.

To prevent deterioration of the present Northwest Channel, the forces which have kept it open must be interferred with as little as possible.

To be able to take full advantage of the depth in the entrance it should be protected from storm waves if possible.

A training-wall on the east of the present channel, starting from near station 1 and extending to the 24-foot contour, would effectively turn the entire flood currents of the Northwest Channel across the bar, and would prevent any cross-flow on the bar. On the other hand it would be very long and expensive; it would induce an unknown quantity of the ebb-flow from the west through the Northwest Channel, with the danger of bringing with it large volumes of sand, which under the present conditions are kept out.

A training-wall west of the channel reaching from the reef near the light to the 24-foot contour would be comparatively short, would prevent cross-currents, would prevent the present spread of the Northwest Channel floods to the west, would partially protect the channel from wave action (it will be remembered that the heavy waves are always from the northwest), and would change but very little the present condition of ebb-flow in the Northwest Channel. On the other hand, if placed to the west of the old rock channel its power of concentration of the flood currents might be so small as to be ineffective.

A training-wall on the west, combined with a wall on the east, located on the edge of the channel between stations 7 and 10, it is believed, would give the necessary concentration of the flood currents and protect the bar channel from cross currents, without materially increasing the ebb-flow across the bar. These walls could be extended to any height and length necessary, and their action assisted by dredging. Later, if necessary, a breakwater could be built to protect the entrance. Such a system would be sufficiently elastic to give the freedom of action so absolutely necessary to the engineer in charge of works of this character.

Should it be decided to provide for a depth of less than 20 feet, I would respectfully adhere to my original recommendation for the position of the training-wall.

The estimated cost of a training-wall on the west side, from the reef northwest from the light-house to the 24-foot contour, is $912,000. Of the training-wall on the east side the estimated cost is $305,000. Allowing for all contingencies, a depth of 24 feet can probably be attained at a cost not exceeding $1,500,000.

To facilitate the investigations into the action of the currents a relief map of the area under consideration has been prepared, at the suggestion of your Board, and is presented herewith. The horizontal scale is $\frac{1}{12000}$, the vertical $\frac{1}{360}$. This distortion is necessary in order to show the inequalities of the sand. The map was constructed by the well-known method of superposing thin layers of wood cut to fit the various contours (in this case half-fathom contours), with intermediate depth, filled out with wax, as described at length in the paper read in 1887 by Messrs. John H. Harden and Edward B. Harden before the American Institute of Mining Engineers. A plaster negative was cast from this model and from this a plaster positive was made. The details of construction were supervised by Mr. Sackett.

Very respectfully, your obedient servant,

W. M. BLACK,
Captain of Engineers.

Col. HENRY L. ABBOT,
Corps of Engineers, Bvt. Brig. Gen., U. S. A.,
President of Key West Harbor Board.

Table of borings.

No. of boring.	Classification.		No. of boring.	Classification.		No. of boring.	Classification.		No. of boring.	Classification.	
	Surface.	Bottom.		Surface.	Bottom.		Surface.	Bottom.		Surface.	Bottom.
1	1[a]	2	34	3	....	68	2	3	102	.....	.....
2	2	3	35	2	.....	69	2	3	103	3	.....
3	2	4	36	2	.....	70	3	5	104	3	6
4	3	3	37	3	.....	71	5	5	105	3[h]	3
5	3	5	38	3	....	72	2	2	106	2	3
6	3	5	39	2	5	73	.....	.....	107	2	5
7	4	4	40	2	5	74	4	.....	108	2	3
8	3	5	41	2	3	75	2	6	109	2	4
9	3	4	42	3	.....	76	2	3	110	2	2
10	4	4	43	3	([d])	77	2	3	111	2	2
11	4	3	44	3	.....	78	3	3	112	2	3
12	.....	.....	45	3	7	79	3	2	113	3	3
13	4	3	46	2	3	80	2	5	114	3	5
14	3	.....	47	2	3	81	3	5	115	3	5
15	3	5	48	2	5	82	2	3	116	3	3
16	3	2	49	3	2	83	3	3	117	5	3
17	3	5	50	2	5	84	3	5[f]	118	3	3
18	3	4	51	2	3	85	3	5	119	3	4
19	2	4	52	3	5	86	5	6	120	3	5
20	3	3	53	2	.....	87	.....	.....	121	2	3
20[a]	3	([b])	54	2	2	88	.....	.....	122	2	5
21	5	([c])	55	3	([e])	89	.....	.....	123	3	4
22	3	.....	56	1	.....	90	3	5	124	4	4
23	5	.....	57	1	.....	91	3	5	125	4	5
24	5	([d])	58	2	.....	92	2	5	126	2	5
25	5	.....	59	.....	.....	93	2	3	127	2	3
26	3	.....	60	.....	.....	94	2	5	128	2	3
27	3	.....	61	3	2	95	5	2	129	3	3
28	3	5	62	2	.....	96	5	2	130	3	3
29	3	.....	63	3	3	97	2	5	131	3	3
30	3	.....	64	2	2	98	3	6[g]	132	2	6
31	3	.....	65	2	3	99	3	7	133	3	3
32	3	.....	66	2	3	100	1	.....			
33	3	.....	67	2	3	101	1	.....			

[a] Fine sand with light live shells.
[b] Fine sand and marl.
[c] Fine dark vegetable matter, depth 14.2.
[d] Rock fragments and fine sand.
[e] Rock and coarse shells.
[f] White and soft.
[g] Mixed with rock.
[h] Small.

REPORT OF MR. J. W. SACKETT, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
St. Augustine, Fla., September 20, 1889.

CAPTAIN: I have the honor to submit the following report upon the survey of the Northwest Entrance, Key West Harbor, Florida, made in April, May, and June, 1889.

The data required as specified in your instructions to me were:

First. A series of current observations at ten stations, six east of and four west of the bar channel, taken simultaneously in sets of six, station 1 always being included in each set.

Second. Borings along lines aggregating in length 9 miles, together with such others as the field work indicated as it advanced would be necessary to develop the contours of the rock in the vicinity of the bar channel.

Third. Soundings sufficient to show the changes since the survey of 1886–'87, and to fill in blank spaces on the map.

The locations of the current stations, the lines for borings and places where soundings were especially desired, were duly designated on the map.

It was decided to begin the current work at once, and during the intervals, which would necessarily occur, to take the borings, leaving the soundings until the current work and the borings were completed.

Besides my two assistants, Messrs. A. C. Harper and J. L. Brownlee, the party consisted of six recorders, eight boatmen, two tide observers, and a cook. The outfit consisted of a fifteen-ton schooner, a small steam-launch, and seven row-boats. The boring and current apparatus and the methods used were described in my report of June 24, 1889, to which I respectfully invite attention.

CURRENT OBSERVATIONS.

The current stations were numbered 1, 6, 7, 8, 9, 10, 11, 12, 13, and 14, the first six being east of and the others west of the bar channel. Six parties were fitted out with the necessary appliances to observe the direction and velocity of the top, mean, and bottom currents, enabling simultaneous observations to be made at six stations as directed. The appliances and the manner of use are described in my report previously referred to.

Two days were required for each complete set of observations. Stations 1, 6, 7, 8, 9, and 10 were occupied one day, and stations 1, 10, 11, 12, 13, and 14 the other. This enables comparison to be made of the results of each day's observations at stations 1 and 10 to show how nearly equal the conditions were. If no great discrepancies were shown it could be assumed that the observations were made simultaneously at all the stations.

Former experience had shown that it would probably require an extended series of observations to obtain one complete set under normal conditions of the governing influences, and also to enable unskilled observers to acquire the necessary dexterity in manipulating the apparatus. After having drilled the observers several times the ebb tide was observed April 16 and 17 and the flood on April 23 and 24. It then became evident that it would be desirable to obtain both the ebb and flood tides on the same day. The time of slackwater and the time and direction of the maximum flow being best defined and most uniform at station 1, it was adopted as the standard with which the other stations could be compared. The times of slackwater at station 1 determined the days selected for observations. As it was estimated that low-water slack would occur at about 5 a. m., May 2, it was decided to attempt to secure both tides on that day and the following one. To do this it became necessary to arrange the apparatus in the boats the night previous and to leave the schooner with the boats in tow of the launch before 3 a. m., as the boats should be in position before slackwater at station 1. To the difficulty of finding the stations in the dark was added the considerable distance it was necessary to traverse, amounting to 8 miles on one day and 12 on the other.

So far no observations had been made during a mean range of the tide. A complete record of the rise and fall of the tide was kept at the light-house, which was plotted daily, as shown on Plate 3. From this, by following precedents, I was able to precict a few days ahead the probable condition of the tide, and in this way I selected May 10 and 11 as the days on which the tide would be near an average range. May 12 would have given a more uniform range than the 10th, but the time of the second high-water slack would have come too late to get complete flood tide. Had the 10th proved unsatisfactory, the observations would have continued on the 12th.

A complete record of the results of the current observations is shown on Plate 2. This table was prepared principally for the purpose of showing the directions and velocities of the currents on the relief map.

Contrary to our observations made previously, the observations made during this survey have shown the ebb tide to be stronger than the flood. This is probably the result of observing day tides only, as changes in the sun's declination would cause corresponding changes in the times of the greatest rise and of the greatest fall of the tide, the former occurring in the day time and the latter at night during the winter and the reverse during the summer; although it does not always follow that the volume of water passing through the Northwest Channel is proportionate to the amount of rise and fall of the tide at Northwest light-house, still under normal conditions the tendency to this relation is quite apparent.

For the purpose of comparison, using the time of slackwater at station 1 to mark the beginning and ending of the tides, each tide has been divided into ten stages of equal duration. The direction and velocity at the middle of each stage were the ones considered.

The results of the observations of May 10 and 11 are shown on Plate 4 in diagrams which show graphically the direction and velocity of the currents at each station for each stage of the tide. On the same sheet the observations of November 26 and 30, 1888, and those of May 10 and 11, 1889, giving fourteen stations in all, are shown in combination on one set of diagrams. As directed by you, on this sheet, is also shown the velocities and directions for all stages at each station on separate diagrams.

Plate 3 shows the velocity curves at each station, together with the tidal curves at the Northwest light-house, and also the tidal curves for Fort Taylor, constructed from the predictions in the U. S. Coast Survey Tide Tables for May 10 and 11. It will be noticed that the predicted times for high and low waters at Fort Taylor occur from forty to fifty-five minutes before the actual times of the corresponding slackwaters at station 1. In plotting the Fort Taylor curves it is assumed that the level of mean tide at both places is the same. It is more than likely that this is not the case. The causes that produce the greater range of tide at the Northwest light-house may operate so as to make the high water higher, without materially affecting the low water, or *vice versa*.

From a few observations it was noted that the vessels at Key West indicated slackwater about twenty minutes before slackwater at station 1.

Plate 3 also shows the complete tidal curve at the Northwest light-house from April 10 to June 14, together with the corresponding positions and phases of the moon. An inspection of this shows that the tides followed the changing conditions of the moon with remarkable uniformity, which would indicate that the water was at its average level during the survey.

As directed by you, sheets 1, 2, 3, and 4, Plate 5, were prepared. Sheets 1 and 2 show the directions and velocities of the currents with reference to ebb and flood stages respectively at station 1. Sheets 3 and 4 show the same with reference to station 14. The diagrams are arranged on the sheets in the true relative positions of the stations which they represent on the scale of the accompanying map.

The water was remarkably clear during nearly the entire survey, so much so that the bottom could be discerned plainly in three fathoms. This incidentally led to casual observations of the appearance of the bottom, particularly at the current stations. A water glass (a large bucket with a glass bottom) was used for this purpose, and with it the grains of sand on the bottom were plainly visible. Rock bottom, or "bar" as it is locally termed, always appeared to have a growth of "feathers," "fans," and sea-weed, a kind of vegetation which I am told is always a characteristic of it. Frequently it has what are called "yellow heads," masses of living coral spherical in shape, supported above the general level of the bottom by a short "neck" generally of less diameter than the portion above. These are of all sizes up to 4 or 5 feet in diameter.

Where the bottom is undisturbed by the currents or by wave action it is generally covered with grass. Where there is neither rock nor grass the bottom is white sand.

Current stations 1 and 9 were in rock bottom. Station 6 was in grass bottom. The other stations were in white sand bottom.

The depths at mean low water at the different stations were as follows:

	Feet.		Feet.
Station 1	25.1	Station 10	10.3
Station 6	17.1	Station 11	14.8
Station 7	7.8	Station 12	13.2
Station 8	10.3	Station 13	10.1
Station 9	11.9	Station 14	29.4

Sand waves were found at each of the stations where the sand was bare. We observed that the wave crests were at right angles to the direction of the current. The wave length seemed to increase as the velocity of the current increased until the maximum current velocity was attained, when the wave length in feet was about two-thirds the entire velocity in feet per second. It then remained about the same

until the current changed its direction, when the waves would become obliterated. In the course of about half an hour after the current had assumed a definite direction the waves were re-formed correspondingly. The rate of advance seemed to be about one-fiftieth of the velocity of the current.

The slope of the side toward the current was about 1 on 5; on the other side it was about 10 on 4.

At no time during these observations did the current exceed 1.5 feet per second.

On the sand bores two-thirds of a mile northeast of station 1 the sand is quite coarse, and while passing over them in about 7 feet of water, with a current setting across them to the south probably less than 3 feet per second, sand waves were seen that were as much as 7 feet apart and 1 foot high, and the sand seemed to be all in motion.

BORINGS.

The borings were taken as directed and their location is shown on the map (sheet 1, Plate 1), their locations and numbers are shown on sheet 4, Plate 1, and the depths to rock at the borings, together with the rock contours, are shown on sheet 3, Plate 1.

The methods employed and a description of the apparatus used is given in my report of June 24, to which I respectfully refer.

SOUNDINGS.

It was found necessary to make an entire resurvey, as the soundings could not be made to fit in with those taken in 1886–'87 with sufficient accuracy, as some changes had taken place, which were afterwards found to be slight, but enough to make the result confusing. The method used in taking the soundings has also been described in the report previously referred to.

The following maps and diagrams are herewith respectfully submitted:

Plates 1, 2, 3, 4, and 5, consisting of ten sheets.

Very respectfully, your obedient servant,

J. W. SACKETT,
U. S. Assistant Engineer.

Capt. W. M. BLACK,
Corps of Engineers U. S. A.

P 5.

IMPROVEMENT OF CALOOSAHATCHEE RIVER, FLORIDA.

The Caloosahatchee River rises in the saw-grass region west of Lake Okeechobee and flows west into San Carlos Bay. Between the mouth and Fort Thompson, 22 miles west of Lake Okeechobee, the river banks are generally high, and the country bordering the river is covered with a dense growth of large trees, principally pines, palmettoes, and oaks. East of Fort Thompson the low saw-grass region begins. The entire river valley as far down as Alva, about 20 miles by river below Fort Thompson, is more or less subject to overflow by the water coming from the Okeechobee Basin. For 21 miles from its mouth the river is broad and has a channel depth of from 6 to 20 feet, with the characteristics of an estuary. This portion of the river is obstructed by oyster bars. Great beds of snags obstruct the upper river. From Alva down the country is being settled for the culture of sugar-cane, pine-apples, cocoa-nuts, oranges, limes, and lemons. Fine cattle ranges exist along the upper river.

Fort Myers, a depot for supplies during the Seminole war, is a thriving town 17 miles from the mouth.

Under the laws of the State of Florida the Atlantic and Gulf Coast Canal and Okeechobee Land Company is engaged in draining the Okeechobee Basin, having authority from the State to cut canals and use

the natural water-ways for that purpose. A canal, with a minimum cross-section of 22 feet by 5 feet, has been opened from Lake Okeechobee to the headwaters of the Caloosahatchee River, and through them as far as the western end of Lake Flirt. A rocky ledge at Fort Thompson has been removed and four cut-offs have been made across the worst bends below Fort Thompson. These works were not intended for the benefit of navigation, but they have incidentally opened a water route about 300 miles long from the Gulf of Mexico to the interior of Florida via San Carlos Bay, the Caloosahatchee River, Lake Okeechobee, the Kissimmee River, and Lakes Kissimmee, Cypress, and Tohopekaliga. Steamers now pass over the route at irregular intervals.

An examination of the river, with a view to its improvement, was made in March and April, 1879. A report thereon, dated August 27, 1879, with a plan of improvement, is printed as Appendix J 17, Report of the Chief of Engineers for 1879.

The project adopted in 1882 called for deepening the channel by dredging from the mouth to Fort Myers, so as to give a depth of 7 feet at mean low water for a width of 100 feet. In 1886 and 1888 this project was modified so as to include the improvement of the upper river as far as Fort Thompson by the removal of snags and overhanging trees and by deepening the channel near Beautiful Islands.

OPERATIONS PRIOR TO JUNE 30, 1889.

Operations were carried on under four appropriations made in acts of 1882, 1884, 1886, and 1888, aggregating $24,000. In 1885 the 7-foot channel through the lower river was reported completed. In 1886–'87 the operations were confined to clearing snags and overhanging trees from the river between Forts Denaud and Thompson, and in making an instrumental survey of the entire river. This survey shows the existence of a practicable channel 6 feet deep and at least 100 feet wide from the mouth to Fort Myers. It also shows that excepting near the Beautiful Islands the channel has sufficient depth and width to permit boats of 4 feet draught to ascend the river as high as Fort Thompson. The upper river is, however, badly obstructed by snags and overhanging trees, only a short reach 4½ miles long having been cleared by the work during May and June, 1887.

OPERATIONS DURING THE FISCAL ENDING JUNE 30, 1890.

Operations on the river were postponed until the services of the United States snag-boat *Suwanee* should become available. On February 14, 1890, she arrived at Fort Myers and on February 22 dredging was begun in the channel near the Beautiful Islands. After making a cut 35 feet wide, 400 feet long, and 5 feet deep through the shoals, the snag-boat proceeded up the river to Fort Thompson, removing all of the worst obstructions; 584 overhanging trees were trimmed and cut, 1,391 snags and stumps, and 200 cubic yards of sand, marl, etc., and 2.7 cubic yards of rock were removed from the channel. Some of the snags weighed from 10 to 12 tons. Two short cut-offs were opened by dredging and by cutting with the boat's wheel.

The boat returned to Fort Myers on May 28. On June 4 the construction of a pile training-wall for the protection of the dredged cut was begun at the Beautiful Islands. The wall consists of a row of piles in juxtaposition driven to hard bottom with a light waling strip on each side. A layer of brush 4 feet wide is placed at the foot of the piles and

held down by stakes and by a layer of shell and stone. Against this it is proposed to deposit the material dredged from the cut. At the end of the fiscal year 1,300 piles had been sunk to hard bottom at a depth varying from 5 to 9 feet; 1,157 feet of waling had been attached and 242 cubic yards of brush had been placed at the foot of the piling, staked fast and covered with 186.5 cubic yards of shell.

MATERIALS AND METHODS.

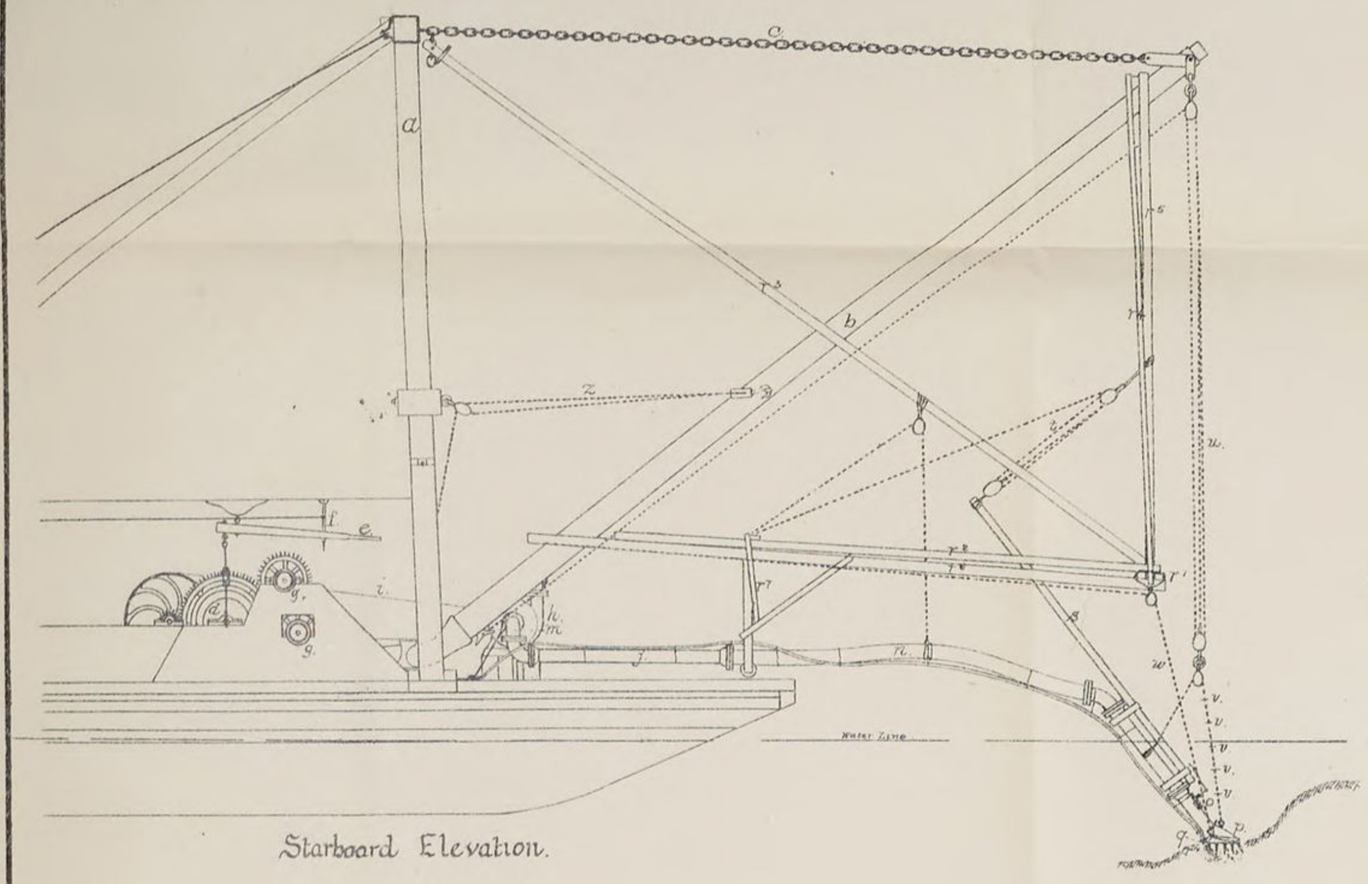
The materials used in the construction of the training-wall are palmetto piles costing 30 cents per log, mangrove brush in bundles costing $1.50 per cord, oyster-shells costing 95 cents per yard, and stone at $1.25 per yard, all delivered at the site of the work. The piles were set by a water-jet in the following manner: A lighter was moored parallel and close to the line of the proposed wall; along the outer side of the lighter a rope was placed, with some slack, and made fast by its ends to the ends of the lighter; on this ran a sheave to which was attached the backstay of a pair of shears by which the piles were raised and placed in position; a weight was then placed on the pile, which was given a slight vibratory movement while the water-jet from the snag-boat pump was applied. From 100 to 175 piles were placed in a day by this method.

The snag-boat is described on page 1350, Vol. 2, of the Report of the Chief of Engineers for 1889.

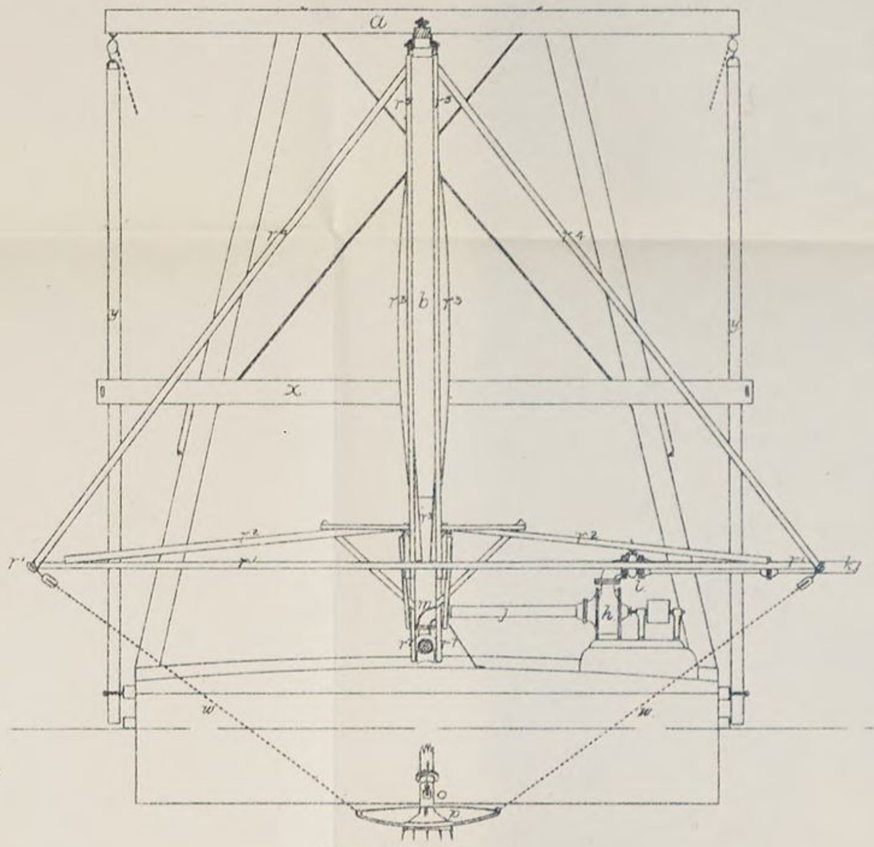
The arrangements for operating the hydraulic dredging apparatus were devised after some trials by Mr. J. W. Sackett, assistant engineer, who has conducted the work in his usual efficient manner. The special difficulties arose from the fact that the dredging had to be done from the bow of the boat, on bars too shallow to permit the passage of the boat and the ordinary method of dragging the cutter; and also that the apparatus had to be such as could be used with the ordinary hoisting machinery for a snag boat. The arrangement of the parts is shown in the accompanying plate. The pump is a six-inch Edward's special cataract pump, and is run by a belt from a fly-wheel on the hoisting-engines. The suction and discharge pipes are 6 inches in diameter. The discharge was over the side. The suction-pipe led direct from the pump to a point under the boom and as close to the boom socket as possible. Here are two quarter bends, attached with a swivel joint having an extra friction ring, for horizontal swinging. The cutter is a hood, shaped like a horse's hoof armed with teeth, with a clear water valve just above it to prevent choking. It cuts when moved in either direction by the boom. The drag lines are attached to a shoe projecting sidewise from the cutter hood and slightly curved up at both ends. The depth of the cut is regulated by the hoisting tackle attached to the hood, and the cutter and pipe are further directed by a pole working between guides. An auxiliary water jet from the boat's donkey-pump is applied close to and under the cutter.

Six men are required to operate—one foreman, one at the engine and drums, one at the hoisting-tackle, one at the guide-pole tackle (he also attends to the clear-water valve), one at the drag-ropes, and one fireman.

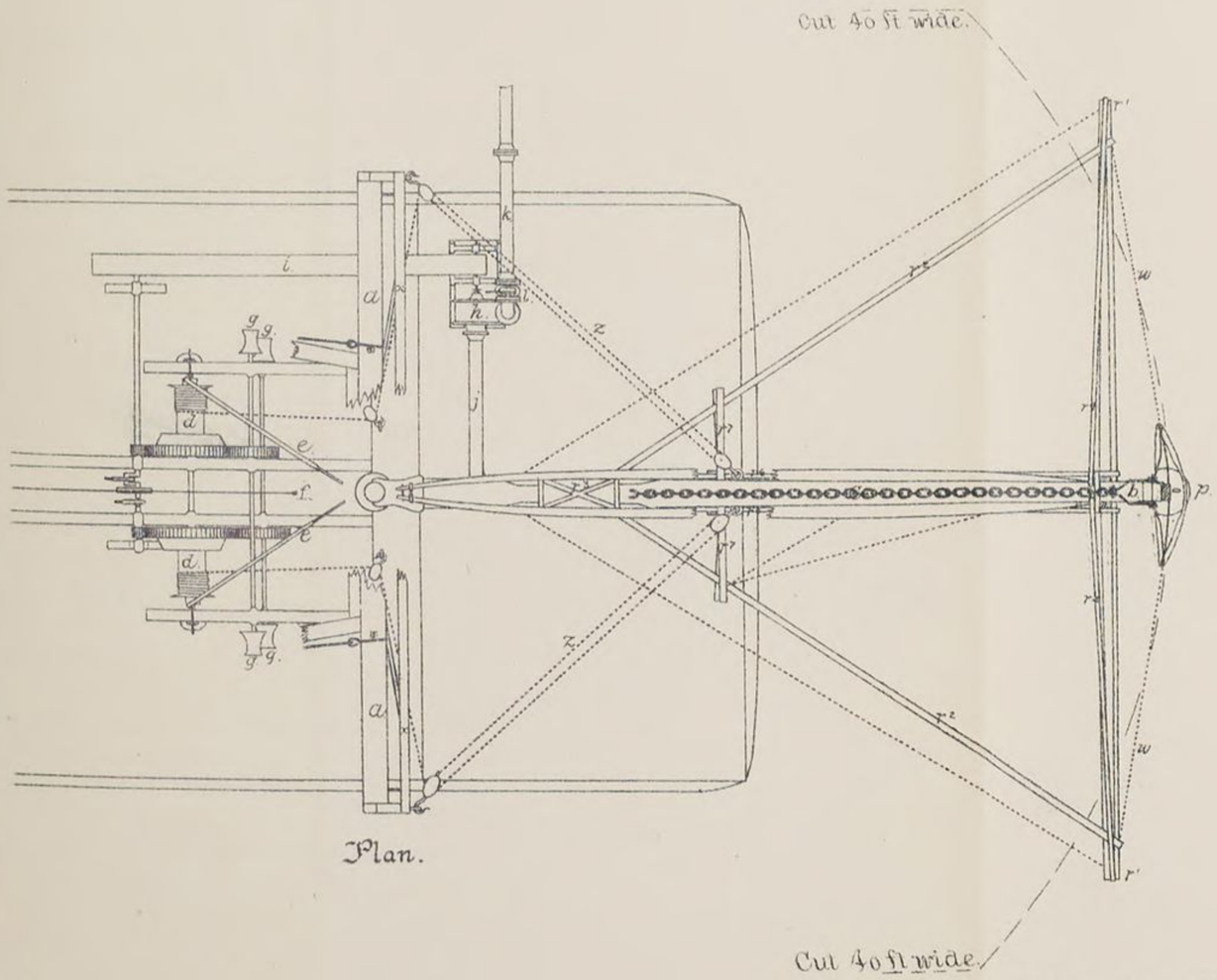
The cut made at each move of the boat was 35 feet wide and 3 feet long. The average amount of solid material was about 25 per cent. of the discharge. As high as 85 per cent. has been taken up. The total capacity of the pump per minute was 1,400 gallons of clear water, or 800 gallons of water loaded with 25 per cent. of heavy material. The best day's work of the pump was 460 cubic yards, but it is believed that with longer experience an average greater than this can be maintained. After discharge the mud, which formed about 30 per cent. of the dredged



Starboard Elevation.



Bow Elevation.



Plan.

Bow of Steam Snag Boat Suwanee, as rigged for Hydraulic Dredging. Caloosahatchee River Improvement. 1890.

Scale 1/120. FEET.

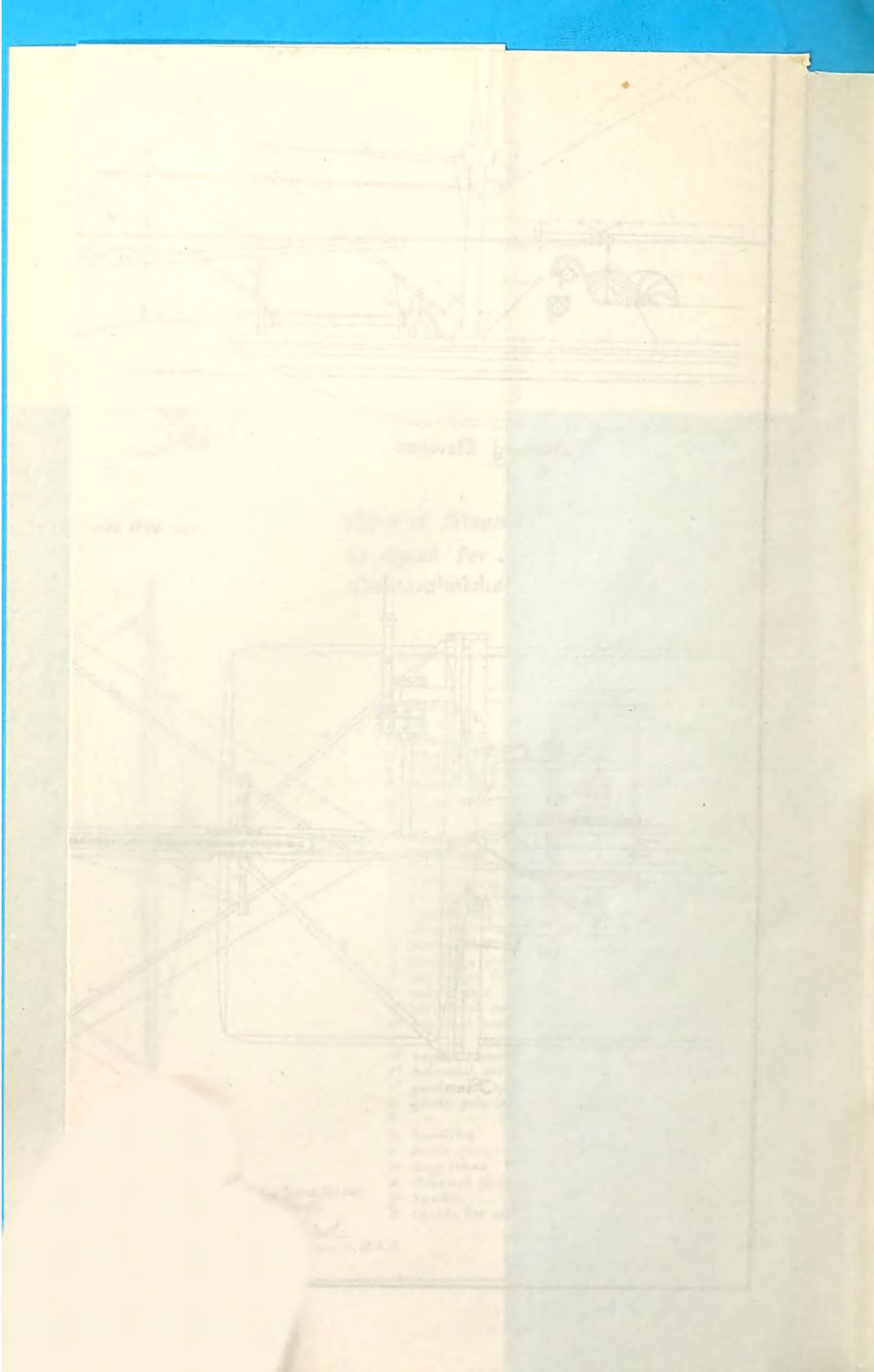
References.

- *a* A frame.
- *b* boom.
- *c* topping-lift.
- *d* hoisting drums.
- *e* friction-clutch levers.
- *f* throttle lever.
- *g* gypsy heads.
- *h* pump.
- *i* driving belt.
- *j* suction pipe.
- *k* discharge pipe.
- *l* quick opening gate valve.
- *m* swivel bend (for horizontal swing of suction pipe).
- *n* flexible pipe.
- *o* clear water valve.
- *p* suction hood.
- *q* auxiliary water jet.
- *r* outrigger Frame, (Bolted together and easily removed)
- *r'* outriggers.
- r^2 horizontal braces.
- r^3 diagonal boom brace.
- r^4 " outrigger braces.
- r^5 vertical boom ties.
- r^6 horizontal struts and guides.
- r^7 guide and hanger.
- *s* guide pole (adjustable).
- *t* " " tackle.
- *u* hoisting "
- *v* depth gauge marks.
- *w* drag lines.
- *x* channel plates of A frame.
- *y* spuds.
- *z* tackle for swinging boom.

U.S. Engineer Office,
St. Augustine, Fla., June 30, 1890.
To Accompany annual report.

W. M. Black
Captain of Engineers, U.S.A.

Photo-Lith by A. HOEN & CO. Balto. Md.



material, floated for some distance, but the sand was deposited within 20 to 40 feet from the end of the pipe.

The boat has proved herself to be excellently adapted for all of the work required of her.

Operations will be continued until the exhaustion of the appropriation. Boats can now navigate the river as far as Fort Thompson. Some few obstructions remain, which can be cleared away at an estimated cost of $3,600, as stated in the last annual report.

Caloosahatchee River is in the collection district of Key West, which is the nearest port of entry; nearest light-house is Sanibel Island Light, and the nearest fort is Fort Taylor.

Money statement.

July 1, 1888, amount available		$9,238.82
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$5,393.35	
July 1, 1890, outstanding liabilities	1,195.54	
July 1, 1890, amount covered by uncompleted contracts made during fiscal year ending June 30, 1890	1,082.00	
		7,670.89
July 1, 1890, balance available		1,567.93
Amount appropriated by act of September 19, 1880		3,600.00
Amount available for fiscal year ending June 30, 1891		5,167.93

COMMERCIAL STATISTICS.

Commerce of Caloosahatchee River, Florida, during the year ending December 31, 1889.

Articles.	Quantity.	Estimated value.	Gross tonnage.
Fertilizers, manufactured ..... tons..	75	$1,875.00	75
Fish and oysters ..... barrels..	1,200	6,000.00	120
Fruits ..... boxes..	60,000	135,000.00	2,100
Grain, breadstuffs ..... bushels..	96,000	96,000.00	2,400
Hides ..... number..	72,000	4,320.00	148
Honey, sirup, etc ..... gallons..	2,940	1,470.00	12
Lumber:			
Rough ..... feet..	1,200,000	14,400.00	2,700
Sawed ..... B. M..	1,000,000	150,000.00	2,250
Merchandise ..... tons..	8,200	410,000.00	8,200
Ship stores ..... do...	3	45.00	3
Vegetables ..... boxes..	1,800	3,150.00	36
Passengers ..... number..	4,000	8,000.00	300
Crate stuffs ..... do...	100,000	12,000.00	500
Total	.....	842,260.00	18,844

Increase due to improvement, 33⅓ per cent.

Vessels.	No.	Tonnage.	Draught of water.
			Feet.
Steamer (triweekly) Alice Howard	1	35	3
Schooners (monthly)	2	*60	4
Schooners (semimonthly)	4	*20	2½
Steamer (in winter)	1	70	4½

*Each.

Total trade of neighborhood carried by water. Probable increase of trade were the improvement completed, 300 per cent.

Remarks.—The general opinion is that with an increase of work on the contemplated improvements the increase of trade on the Caloosahatchee River is incalculable. A very large area of country south of this river depends on it for transportation facilities.

HENRY MARCOTTE.

P 6.

IMPROVEMENT OF PEASE RIVER, FLORIDA.

Pease River (Talakchoboko, Hatchee, or Peaseating Creek) rises in the northeastern part of township 30 south, range 26 east, and flows northwestward and westward to the middle of section 33, township 29 south, range 25 east, where it makes a junction with Saddle Creek, flowing southeastward from Lake Hancock; thence its course is southwest to Hickory Bluff, where it empties into Charlotte Harbor, making about 15 miles westing and 66 miles southing. It is fed by numerous lakes in the central part of Polk County. The principal tributaries in the east are Little Charley, Tsala-apopka, Josh, and Prairie creeks, and on the west Saddle, Whitten, and Chilocohatchee creeks. Besides these streams wide areas of swamp and hammock lands, immediately bordering the river and the more elevated adjacent pine lands are covered, during the rainy season in July and August, with shallow pools of water, which are discharged for the most part into Pease River. The stream, therefore, exhibits much variation in its stages of water, the range between extremes at Fort Meade being about 17 feet.

For the last 10 miles of its course the river has the characteristics of an estuary, and is in fact the prolongation of Charlotte Harbor. Vessels drawing 10 feet of water can enter the mouth. Five feet can be carried to Cleveland, 7 miles from the mouth.

PROJECT OF IMPROVEMENT.

The proposed improvement consists in rock excavation, removing snags, and clearing the banks of overhanging trees, so as to open the river for navigation by boats drawing 2 feet of water to navigate during about half the year, the minimum channel width to be 30 feet.

OPERATIONS PRIOR TO JUNE 30, 1889.

Operations were carried on by hired labor under appropriations made in 1881 and 1882, aggregating $11,000. The work was done over a reach of 64 miles, beginning at the mouth. The channel was cleared through the distance traversed, but with no practical results. There is no regular navigation in the river, and the stream has again become choked with bars and fallen trees.

In the act approved August 5, 1886, an appropriation of $13,000 was made "for improving Manatee and Pease rivers." Of this an allotment of $2,000 was made by the Secretary of War for making a survey and map of the river. In April, 1888, an examination of the commercial interests of the stream was made by Lieut. D. D. Gaillard, Corps of Engineers. There were no operations during the fiscal year ending June 30, 1890.

The improvement of the river from Fort Meade to its mouth is greatly desired by the inhabitants of the neighboring country, so as to permit competition for freights with the Florida Southern Railway, which is now the only means of transportation available. Some dredging is needed at the mouth of the river to permit the Morgan Line of steamers, which touch there, to reach their wharf without delay during all states of wind and tide. Large beds of phosphates have been discovered along the bed of the stream, and shipments by water from Punta Gorda have been

begun. The development of this industry will increase very greatly the commercial importance of the river. Owing to the bar below Punta Gorda and the shoals off Cape Haze, in Charlotte Harbor, steamers can load with phosphate at Punta Gorda to a depth of about 10 feet only, and the remainder of the lading must be completed by lighterage to near the Boca Grande entrance of Charlotte Harbor. So that at present the phosphates are dredged from the stream near Arcadia, carried by rail to Punta Gorda and the bulk then lightered out to the entrance of Charlotte Harbor.

The estimated cost of clearing the upper river is $25,000, and of dredging at the mouth, $30,000. Should appropriations for the work be made in small amounts these estimates will have to be largely increased. No project has been submitted for the development of the channel near Cape Haze and its cost is not known.

Pease River is in the collection district of Key West, and Tampa is the nearest port of entry; nearest light-house is Charlotte Harbor Light, and the nearest fort is Fort Taylor.

Money statement.

July 1, 1888, amount available		$30.25
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$11.75	
July 1, 1890, outstanding liabilities	18.50	
July 1, 1890, amount covered by uncompleted contracts made during fiscal year ending June 30, 1890		30.25
Amount (estimated) required for completion of present project		25,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		10,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

Commerce of Pease River, Florida, during the year ending December 31, 1889.

Articles.	Quantity.	Estimated value.	Gross tonnage.
Fertilizers, manufactured ..... tons..	80	$2,000	80
Fruits ..... boxes..	30,000	67,500	1,050
Grain, breadstuffs, etc ..... bushels..	70,440	35,220	1,761
Hides ..... number..	3,000	3,240	27
Honey, sirup, etc ..... gallons..	3.200	1,600	13
Lumber, sawed ..... B. M..	200,000	20,000	4,500
Merchandise ..... tons..	1,150	57,500	1,150
Vegetables ..... boxes..	200	350	4
Phosphates ..... tons..	6,000	30,000	6,000
Total	.....	217,410	14,585

Small craft, flats, etc., aggregating 300 tons, draught of water various, to 2½ feet.

Estimated percentage of total trade of neighborhood carried by water, 20; probable increase of trade were the improvement completed, incalculable.

Remarks.—About 20 per cent. of the above goods is carried from Punta Gorda to the mouth of Pease River (or creek) by water for distribution to up river points by railroad. A large share of the phosphates is floated down the river to Punta Gorda, owing to the want of depth of water to float sea-going vessels at the mouth of the river. The improvements are a necessity.

HENRY MARCOTTE.

P 7.

IMPROVEMENT OF MANATEE RIVER, FLORIDA.

Manatee River rises in the southern part of Florida and flows in a westerly direction, emptying into Tampa Bay on its southern shore. For a distance of 12 miles from its mouth it has the characteristics of an estuary. For 10 miles the settlements along its banks are almost continuous. They comprise the towns of Manatee, Hendrix, Ellenton, Palmetto, Braidentown, and Palma Sola. Oranges and vegetables are raised in large quantities. From the fine ranges along the upper river hides, wool, and sheep-skins are exported.

In the estuary the general depth of the river varies from 7 to 20 feet. At the mouth there is a long shoal with a depth of 7 feet. Between Palmetto and Manatee there is another bar covered by from 3 to 5 feet of water.

An examination of Manatee River, with a view to its improvement, was made in 1881. A report thereon, dated February 16, 1882, with plan of improvement, is printed as part of Appendix K 25, Annual Report of the Chief of Engineers for 1882.

PROJECT OF IMPROVEMENT.

The original project had for its object to form a channel 100 feet wide and 13 feet deep at mean low water, from Tampa Bay to Shaw's and McNeil's points, a distance of about 4 miles. The available depth before improvement was 8 feet.

Since the original project was adopted railroad and steam-ship lines have been established, which make Tampa the distributing point for the neighboring portion of Florida. Accordingly it was decided to modify the project for the improvement of Manatee River, so as to open up the entire lower river to light-draught boats which would connect with the transportation lines centering at Tampa. The project, as modified, calls for the formation of a channel 100 feet wide and 8 feet deep at mean low water from Tampa Bay to Manatee.

OPERATIONS PRIOR TO JUNE 30, 1889.

In 1883–'84 a dredged cut was made across the bar at the mouth of the river with an appropriation of $12,000, made in the act passed August 2, 1882. In the act approved August 5, 1886, $13,000 were appropriated for "improving Manatee and Pease Rivers." Of this sum $11,000 were allotted for work in Manatee River. With this the river was surveyed and mapped from the mouth to the head of navigation at Mitchellville, 12 miles above Rocky Bluff, and a dredged cut 65 feet wide, 8 feet deep, and 2,400 feet long was made through the bulkhead between Manatee and Braidentown.

In the act of August 11, 1888, $5,000 were appropriated for continuing this improvement. Owing to the presence of yellow fever in the State, no work was finished before the end of 1888. On December 28 bids were requested for widening the dredged cut between Manatee and Braidentown. The bids were to be opened January 28, 1889. There was only one bid, which was rejected as being too high. On March 6, 1889, a contract for doing the work for 29 cents per cubic yard was entered into with Mr. D. G. Ambler, of Jacksonville, Fla., which was approved by the Chief of Engineers March 22, 1890.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

On July 31, 1889, the contractor's plant arrived at the site of the proposed work. Dredging operations were started soon thereafter, but the plant, though new, proved so defective, that work had to be discontinued until the plant could be entirely overhauled.

Dredging was recommenced October 9, 1889, and prosecuted continuously to completion on December 23, 1889, on which date 14,977.05 cubic yards of material had been removed under this contract.

The work done consisted in widening the cut on the south side 40 feet, removing the shoal places in the old cut, and slightly belling the ends of the completed cut.

When work was completed the channel was 105 feet wide through the middle portion, somewhat wider at the ends, and between 8 and 9 feet deep at mean low water.

An inspection of this cut, made by the division engineer, accompanied by the officer in charge, in January, 1890, showed no appreciable change in its condition.

During the past season steamers have visited the Manatee River daily, running to ports on Tampa Bay.

Manatee River is in the collection district of Tampa. Tampa is the nearest port of entry. Nearest light-house is Egmont Key Light. Nearest fort is Fort Taylor.

Money statement.

July 1, 1889, amount available		$816.21
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$602.68	
July 1, 1890, outstanding liabilites	21.66	
		624.34
July 1, 1890, balance available		191.87
Amount appropriated by act of September 19, 1890		6,000.00
Amount available for fiscal year ending June 30, 1891		6,191.87
Amount (estimated) required for completion of existing project		39,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		5,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

Commerce of Manatee River, Florida, during the year ending December 31, 1889.

Articles.	Quantity.	Estimated value.	Gross tonnage
Fertilizers (manufactured) ..... tons..	475	$16,225.00	475
Fish and oysters ..... barrels..	35,000	21,000.00	3,500
Fruits ..... boxes..	8,500	212,000.00	2,475
Grains and breadstuffs ..... bushels..	140,000	350,000.00	3,500
Hides ..... number..	7,500	7,884.00	66
Honey, sirup, etc ..... gallons..	15,200	8,000.00	61
Lumber:			
Rough ..... feet..	600,000	36,000.00	1,350
Sawed ..... B. M..	325,000	650,000.00	732
Merchandise ..... tons..	4,092	204,600.00	4,092
Ship-stores ..... do....	2	30.00	2
Vegetables ..... boxes..	74,000	150,000.00	148
Passengers ..... number..	10,200	2,500.00	768
Crate stuffs ..... do....	215,000	25,800.00	1,075
Hogs ..... do ...	1,175	6,168.75	44
Total	.....	1,690,207.75	15,138
			3,150
			18,288

Increase due to improvement, 33 per cent.

Commerce of Manatee River, Florida, etc.—Continued.

Vessels.	No.	Tons.	Draught of water.
			Feet.
Steamer Kissimme (tri-weekly)	1	350	8
Steamer Williams (daily)	1	90	4
Sailing craft	*50	†40	3

* Estimated. † Average.

Total trade of neighborhood carried by water. Probable increase of trade were the improvement completed, 100 per cent.

Remarks.—The continued improvement of the Manatee River is a necessity to the welfare of the large area of rich country bordering it, especially as there appears to be no prospect for the building of railroads, and the trade of the river towns is dependent upon the West Indies, Mobile, New Orleans, and the North and West, via Tampa.

HENRY MARCOTTE.

P 8.

IMPROVEMENT OF TAMPA BAY, FLORIDA.

Tampa Bay is a large indentation in the Gulf coast of Florida, with an average width of from 6 to 7 miles, and a length, including Hillsborough and Old Tampa bays, into which its inner end is divided, of 35 miles. Across the bar and up to the point of division, a distance of 25 miles, the channel has a depth of from 20 to 38 feet.

Old Tampa Bay, the northwestern division, is about 10 miles long, with an average width of 5½ miles. Near its mouth there is a channel depth of over 20 feet of water. A depth of 10 to 12 feet extends to its head. Hillsborough Bay has an average width of 5 miles, with depth varying from 16 feet at the mouth to 8 feet near the head. Flats with low-water depth from 1 to 5 feet, varying in width from one-quarter to 1 mile, surround the entire body of water.

Its principal tributary is the Manatee River. The principal town is Tampa, lying at the mouth of the Hillsborough River, at the head of Hillsborough Bay, but separated from the deep water of the bay by a broad flat through which runs a narrow channel formed by the waters of Hillsborough River. Through this, before improvement, vessels drawing 8 feet of water were able to reach Tampa only by taking advantage of high tides.

The South Florida Railway now has its terminus at Port Tampa, near the mouth of Old Tampa Bay, where it makes connection with steam-ship lines for Key West, Havana, Mobile, and Central American ports. Port Tampa is about 9½ miles from Tampa, with which city it is connected by the railway, and for which it is the deep-water port.

An examination of Tampa Bay with a view to its improvement was made in 1879. A report thereon, dated August 25, 1879, with a plan of improvement, is printed as Appendix J 18 to the Report of the Chief of Engineers for 1879.

FORMER PROJECT OF IMPROVEMENT.

The proposed improvement consists in deepening and widening the channel from Tampa to the bay, a distance of 5¾ miles, by dredging and rock excavation, so as to give a clear depth of 9 feet at mean low water, and a width in the river of 200 feet, and in the bay of 150 feet.

OPERATIONS PRIOR TO JUNE 30, 1888.

Work was done by contract under the following appropriations:

By act approved—	
June 14, 1880	$10,000
March 3, 1881	10,000
By act passed August 2, 1882	20,000
By act approved—	
July 5, 1884	20,000
August 5, 1886	10,000
Total	70,000

The work consisted entirely of dredging and rock excavation, and extended over a length of 8,200 feet, making a cut varying from 200 feet in the river to 60 feet in the bay. In the bay it has been partly filled by cross tidal currents. On June 30, 1887, it had a depth along the center line of from 8.3 to 9 feet. The depth in the bay beyond the outer extremity of the cut is 7 feet. The estimated cost of completing the dredged channel called for by this project is $63,000.

MODIFIED PROJECT.

In 1888 the project was changed. It now contemplates the formation and maintenance of a channel 8 feet deep in Hillsborough Bay and Hillsborough River to the city of Tampa, and the formation of a channel 200 feet wide and 20 feet deep at mean low water from the outer bar to Port Tampa.

The estimated cost of the revised project was $60,000. In the act of August 11, 1888, $25,000 were appropriated for this work. Owing to various unavoidable delays the contract for the work was not made until March 22, 1889. Work under the contract began June 29.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

The plant provided for the work proved entirely inadequate, and on July 28 it was removed to Manatee River; the time for the contract having been extended to May 5, 1890. On February 3, 1890, another dredge and plant arrived at the work. Little was done, and on May 5, when the contract time expired, only 14,688 cubic yards had been dredged out of a total estimated volume of 72,000 cubic yards. The contract has not yet been annulled, and the contractor promised to commence dredging with a new and powerful plant at or before the end of July, 1890.

Tampa Bay is in the collection district of Tampa, which is the nearest port of entry. Nearest light-house is Egmont Key Light. Nearest fort is Fort Taylor.

Money statement.

July 1, 1889, amount available		$2,272.97
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$1,235.80	
July 1, 1890, outstanding liabilities	10.10	
		1,245.90
July 1, 1890, balance available		1,027.07
Amount appropriated by act of September 19, 1890		25,000.00
Amount available for fiscal year ending June 30, 1891		26,027.07
Amount (estimated) required for completion of existing project		10,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		10,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

COMMERCIAL STATISTICS.

Commerce of Tampa Bay, Florida, during the year ending December 31, 1889.

Articles, etc.	Quantity.	Estimated value.	Gross tonnage.
Crate stuffs.....number..	300,000	$30,000.00	1,500.00
Fertilizers.....tons..	2,385	56,309.00	2,383.00
Fish and oysters.....barrels..	31,690	61,035.00	3,189.00
Fruits.....boxes..	174,277	435,692.50	7,167.00
Grain and breadstuffs.....bushels..	99,690	99,690.00	2,492.25
Hides.....number..	22,984	24,824.00	207.00
Honey, sirup, etc.....gallons..	20,576	10,288.00	82.00
Lumber (rough).....logs..	196,000	140,000.00	392,000.00
Lumber (sawed).....B. M..	3,000,000	450 000.00	6,750.00
Merchandise.....tons..	12,245	612,250.00	12,245.00
Ship stores.....do....	10	3,000.00	10.00
Vegetables.....boxes..	88,560	132,840.00	2,214.00
Passengers.....number..	71,875	80,000.00	5,385.00
Building materials.....tons..	6,311	213,630.00	6,311.00
Bananas.....bunches..	200,000	200,000.00	800.00
Tobacco.....pounds..	79,875	80,000.00	41.00
Cigars.....do....	30,300	90,900.00	2.00
Havana fruits.....do....	283,800	11,352.00	141.50
Wines.....gallons..	1,196	1,196.00	6.00
Total.....	.....	2,733,006.50	442,925.75

Vessels.	No.	Tons.	Draught of water.
Steamer:			*Feet.*
Olivette	1	1,893	11
Mascotte	1	1,893	11
Juniata	1	354	7
Henderson	1	354	7
Cumberland	1	354	7
Kissimmee	1	350	7
Williams	1	365	4
Chas. Morand	1	761	10
Local (coast)	10	.....	3
Sailing:			
Local (coast)	26	*267	3

*Aggregate.

Estimated percentage of total trade of neighborhood, as given above, carried by water, 75 per cent. Probable increase of trade were the improvement completed, 1,000 per cent.

REMARKS.—These statistics give only the volume of commerce entering and leaving the ports of Tampa and Port Tampa. It is thought that with the improving of the harbor a large portion of the phosphates will attract ocean-going vessels to Tampa, thereby inducing trade with European ports. The trade with the Indies increases continually.

HENRY MARCOTTE.

P 9.

IMPROVEMENT OF WITHLACOOCHEE RIVER, FLORIDA.

The Withlacoochee River rises not far from Kissimmee, south of the center of the peninsula of Florida, and flowing north and west reaches the Gulf of Mexico at a point about 20 miles southeast from Cedar Keys. It has a total length of 120 miles. Pemberton Ferry, made the present head of navigation by the railroad trestle bridge of the South Florida Railroad, is 77 miles from the mouth. The roads of the Florida Railway and Navigation Company and of the Silver Springs, Ocala and Gulf Railroad Company touch the river at Panasoffkee and Dunnellon, respectively 57 and 31 miles from the mouth. The country bordering

the river consists mainly of fine hummock land and cypress swamps. Large quantities of fruits and vegetables are grown and the country is fast being settled. Extensive deposits of phosphates have recently been discovered along the lower river.

The absence of good wagon-roads and of parallel railroads greatly increases the importance of the Withlacoochee River as a means of communication and transportation.

Before improvement this river was so badly obstructed that no regular navigation was possible, and the river was used only for rafting cedar logs or for an occasional push-boat. The obstructions consisted of ledges of limestone rock, sand-bars, snags, and overhanging trees. At certain points the river expands in broad, marshy lakes and cypress swamps, in which there is no clearly defined channel. The general depth was from 1 to 7.5 feet, with a width of from 75 to 180 feet.

Operations for the improvement of this river have been carried on in accordance with the project submitted to the Chief of Engineers in 1879 by the officer then in charge, and published as part of Appendix K 18 to the Annual Report of the Chief of Engineers for 1880.

PROJECT OF IMPROVEMENT.

The project adopted is to improve the river by the removal of snags, overhanging trees, and loose rocks, and the deepening of some of the worst shoals and a bar at the mouth of the river, so as to enable boats drawing 2 feet to navigate the river during about half the year from the mouth to Hay's Ferry, a distance of 71 miles. In 1886 the project was modified to permit the improvement to be continued as far as Pemberton's Ferry, 6 miles above Hay's Ferry.

OPERATIONS PRIOR TO JUNE 30, 1889.

Work was carried on under the following appropriations:

By act approved—	
March 3, 1881	$7,500
July 5, 1884	3,000
August 5, 1886	3,000
By act of August 11, 1888	5,000

The work was done partly by hired labor and partly by contract. The entire river from the mouth to Pemberton Ferry was gone over and the worst obstructions were removed. The reach between Panasoffkee and Pemberton Ferry was made navigable at all stages excepting the lowest. The channel formed there is very narrow and tortuous and throughout the river much remained to be done to complete the improvement as called for by the project.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

Operations were carried on by the United States snag-boat *Suwanee* from July 11 until the end of September, 1889, when work was suspended on account of high water and the steamer taken to another river. Four hundred and forty overhanging trees were cut and 451 trimmed; 47 large snags and trees were removed from the river-bed and 203 cubic yards of rock were blasted. The work was carried on from the mouth to Stokes Ferry and in the neighborhood of Graham's Shoals.

At the close of operations the channel called for by the project had been formed between Pemberton Ferry and Dunnellon, though there

are still obstructions which must be removed before navigation is safe. Between Dunnellon and the mouth are two dangerous rock ledges and many overhanging trees which require removal.

There are several lines of small steamers plying between Pemberton Ferry, Panasoffkee, and landings south of the marshy lake south of Morrison's Landing. There is no regular navigation of the river below Morrison's Landing excepting by timber rafts.

The growing commercial importance of the Withlacoochee River warrants a more extended plan of improvement, and I would renew the recommendations made in the Annual Reports for 1887 and 1888, that the project be modified so as to provide for navigation during the entire year over those portions of the river between Pemberton Ferry and Colton's Grove, and between Morrison's Landing and the mouth. The excepted reach is a broad, marshy lake through which a low-water channel could be formed and maintained only by dredging, to the detriment of the river above.

The estimated cost of this extension of the project is $22,400. Once formed the channel can be maintained at an annual expenditure not exceeding $800. In these rivers a channel is only kept open by constant use. An unused channel is soon rendered permanently unfit for navigation without expensive work by the dams and bars formed by the rapid accumulation of drift-wood and water weeds, so that a complete opening of the river for navigation throughout the year is in the interest of economy, apart from the commercial advantages gained.

Withlacoochee River is in the collection district of St. Marks, Fla., of which Cedar Keys is the nearest port of entry; nearest light-house, Cedar Keys Light; nearest fort is Fort Marion, Fla.

Money statement.

July 1, 1889, amount available	$4,157.10
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	2,427.31
July 1, 1890, balance available	1,729.79
Amount appropriated by act of September 19, 1890	5,400.00
Amount available for fiscal year ending June 30, 1891	7,129.79

COMMERCIAL STATISTICS.

Commerce of Withlacoochee River, Florida, during the year ending December 31, 1889.

Articles.	Quantity.	Estimated value.	Gross tonnage.
Cotton ..... bales..	.....	.....	.....
Fertilizers ..... tons..	60	$1,500	60
Fruits ..... boxes..	60,840	136,890	2,433½
Grain, flour, etc ..... tons..	10,000	300,000	10,000
Hides ..... number..	5,000	9,000	45
Honey, sirup, etc ..... gallons..	7,000	2,450	28
Lumber:			
Rough logs ..... feet, B. M..	6,000,000	36,000	13,500
Sawed ..... do....	700,000	7,000	1,575
Merchandise ..... tons..	16,225	811,250	16,225
Vegetables ..... boxes..	2,980	6,225	190
Passengers ..... number..	8,000	16,000	600
Totals	.....	1,326,315	44,656½

Increase due to improvement, 70 per cent.

Commerce of Withlacoochee River, Florida, etc.—Continued.

Vessels.	No.	Tons.	Draught of water.
			Feet.
Steamer Samuel Pyles	1	54.46	3
Steamer Suwanee	1	28	

Estimated percentage of total trade of neighborhood as given above, carried by water, 20 per cent Probable increase of trade were the improvement completed, 100 per cent.

Remarks.—The phosphate and lumber industries (of 1890) are dependent on improvement of the river.

HENRY MARCOTTE.

P 10.

IMPROVEMENT OF HARBOR AT CEDAR KEYS, FLORIDA.

The harbor at Cedar Keys is the most northern harbor on the Gulf side of the Peninsula of Florida. It is formed by the tidal channels between a group of small islands or keys, of which Way Key, on which is situated the town of Cedar Keys, is the largest. Cedar Keys is the terminus of the central division of the Florida Railway and Navigation Company. Its principal business is in cedar lumber, though it also forms a distributing point for supplies and general merchandise for an area to the north and south.

An examination of the harbor with a view to its improvement was made in November, 1883. A report thereon, together with a plan of improvement, was printed as Appendix N 30 to the Report of the Chief of Engineers for 1884.

PROJECT OF IMPROVEMENT.

The improved project, as there described, is as follows: To obtain a channel 200 feet wide and with a least depth of 10½ feet from Cedar Keys to the Gulf of Mexico. A depth of 9½ feet formerly existed in this channel. The depth is limited by the existence of beds of rock under the entire channel from 9½ to 12½ feet below mean low water, which could only be removed at greater expense than the present and prospective commerce of the port would seem to warrant. The estimated cost of completing this project is $46,500.

On this project appropriations aggregating $19,500 were made by the river and harbor acts of July 5, 1884, August 5, 1886, and August 11, 1888.

OPERATIONS PRIOR TO JUNE 30, 1889.

An improvement was made of this harbor in 1872–1881 as follows: A cut 200 feet wide and 11½ feet deep down to the limestone was made through the Middle Ground; another through the outer bar 200 feet wide and 12 feet deep, excepting at a point 80 feet from the line of black buoys, where the limestone is 11½ feet under the surface; the remaining 120 feet on the east side of the cut being fully 12 feet deep.

Under the appropriation made in 1884 a cut was started through the rock near Buoy No. 12 on October 14, 1885, and continued until the exhaustion of the appropriation. Three hundred and seventy cubic yards of sand and 615.3 cubic yards of rock were removed. To complete the channel at this point to a width of 200 feet and to the desired depth would require the removal of 7,800 yards more, of which one-fourth is rock.

The appropriation of 1886 was expended in re-opening the cut through the Middle Ground. Its direction was changed so as to be as nearly as practicable on the prolongation of the line of the entrance to the ship's channel. The cut made was 1,200 feet long, 70 feet wide, and 10.7 feet deep. This cut was not large enough to maintain itself, and it was determined to expend the appropriation of 1888 in widening it by dredging. From various causes a contract for the work was not entered into until March, 1889, when one was made with Mr. D. G. Ambler for dredging at 29 cents per cubic yard.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

The time for the completion of the work under the contract was fixed at May 5, 1890. At that date nothing had been done. No extension of time was granted to the contractor, but as he was desirous of doing the work, and as it was most advantageous to the United States to have him do so, the contract was not annulled. The dredge arrived at Cedar Keys on May 25. Work was begun on June 2. At the close of the fiscal year 9,180.6 cubic yards had been removed.

The commercial importance of Cedar Keys has steadily declined for some years. About the only water traffic that it has now is carried in very light-draught vessels, for which the harbor in its present condition affords ample facilities. I am unable to discover that there is any immediate prospect of an increase in the commerce of this port, and am of the opinion that the improvement there should be discontinued until an increased commerce, actual or fairly prospective, makes the further improvement necessary.

Cedar Keys is in the collection district of St. Mark's, of which Cedar Keys is the headquarters. Nearest light-house, Cedar Keys light; nearest fort is Fort Marion.

Money statement.

July 1, 1889, amount available		$726.64
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$308.90	
July 1, 1890, outstanding liabilities	189.70	
		498.60
July 1, 1890, balance available		228.04
Amount appropriated by act of September 19, 1890		2,500.00
Amount available for fiscal year ending June 30, 1891		2,728.04
Amount (estimated) required for completion of existing project		44,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

Commerce of Cedar Keys, Florida, during the year ending December 31, 1889.

Articles.	Quantity.	Estimated value.	Gross tonnage.
Fish and oysters ..... bbls..	16,400	$45,500	647½
Grain, flour, etc ..... tons..	8,895	71,160	8,895
Lumber:			
Rough logs ..... feet..	8,000,000	56,000	20,000
Sawed ..... B. M..	5,000,000	50,000	12,500
Merchandise ..... tons..	14,091	1,491,000	14,091
Ship-stores ..... tons..	10	300	10
Passengers ..... number..	4,562	6,700	342
Green turtle ..... pounds..	65,000	6,800	34
Cedar pencil slats ..... feet, B. M..	639,960	570,000	951
Cedar logs ..... feet..	3,060,000	1,071,000	4,590
Totals	.....	3,368,460	62,060½

There is a large decrease in cottons to this port, owing to the need for further improvements in the harbor and at the entrance to the Suwanee River, which will permit of the entrance of vessels of greater draught. The improvements being made are of a permanent nature and will be beneficial to trade.

Vessels.	No.	Tons	Draught of water.
			Feet.
Schooners averaging one trip a year, home ports	3	415	10
		240	9
		47	6
South American, bark	1	381	10
Local fishing, sail	28	392	4

Estimated percentage of total trade of neighborhood, as given above, carried by water, 10 per cent.
Probable increase of trade were the improvement of the Suwanee Basin completed, 100 per cent.

Remarks.—The port of Cedar Keys is crippled for want of the improvements of the Suwanee Basin.

HENRY MARCOTTE.

P 11.

IMPROVEMENT OF SUWANEE RIVER, FLORIDA.

The Suwanee River rises in the southern part of Georgia, near the Okefinokee Swamp, and, flowing in a general southerly direction, empties into the Gulf of Mexico a few miles north of Cedar Keys. The portion examined with a view to its improvement extends from Ellaville to its mouth. The country adjacent is well wooded, and the chief trade is in pine, cypress, and cedar timber, cotton, sirup, the minor farm products, and naval stores.

Previous to improvement the obstructions in this portion of the river consisted principally of shoals composed of soft, unstratified limestone, mixed with flint, extending either partly or entirely across the river; in some instances covered with shallow deposits of sand and in others bare. The channels across these shoals were often narrow and very crooked, and their depths at extreme low water varied from 15 inches to 3 feet.

At other places large isolated limestone bowlders in the channel were constant sources of danger to navigation.

An examinalion of this river, with a view to its improvement, was

made in 1879. A report thereon, dated August 26, 1879, with a plan of improvement, is printed as Appendix J 16, Report of the Chief of Engineers for 1879.

PROJECT OF IMPROVEMENT.

The proposed improvement consists in deepening the bar at the passes by dredging, the removal of snags and overhanging trees along the river, and deepening and improving the channel at various places by the removal of rocks, snags, and construction of dams, so as to strengthen, widen, and deepen the channel. The depth to be obtained is 5 feet through the bars at the passes for a width of 150 feet, and up the river as far as Roland's Bluff, a distance of 74 miles. From there up to Ellaville, a distance of 50 miles, the depth is to be 4 feet and the width 60 feet.

OPERATIONS PRIOR TO JUNE 30, 1889.

Work was done under the following appropriations:

By act approved—	
June 14, 1880	$5,000
March 3, 1881	3,000
By act passed August 2, 1882	5,000
By act approved—	
July 5, 1884	5,000
August 5, 1886	5,000
By act passed August 11, 1888	15,000
Total	38,000

Ten thousand dollars of the last appropriation were "to be expended in the purchase or construction of a suitable steam snag-boat with dredging and pile-driving machinery, to be used on the rivers of the west coast of Florida;" leaving the total amount appropriated for work on the river, $28,000.

Operations under the appropriations of 1880, 1881, 1882, and 1884 consisted entirely of dredging across the Suwanee Basin at the east pass. On this line the distance from deep water of the Gulf to deep water in the river is 15,600 feet. A cut 5,835 feet long, 60 feet wide, and 5 feet deep at mean low water was made, leaving a length of 9,765 feet to be dredged through water having an average depth of 3½ feet. This channel has since partly filled up.

During the fiscal years 1886–'87 and 1887–'88 work was confined to clearing the upper river between New Branford (Roland's Bluff) and Luraville. It consisted in removing snags, and overhanging trees, and blasting and removing rocks from the channel. It was done by hired labor, by a party working from a flat-boat belonging to the United States. The boat built under the appropriation of 1888 is described in Appendix P 11 of the Report of the Chief of Engineers for 1889.

Work with this boat during the fiscal year ending June 30, 1889, was carried on at Derrick Island Pass and Bard's Shoal, and consisted of dredging at the former place, and blasting and removing rock from the channel at the latter place.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1890.

Active work by the United States steam snag-boat was carried on principally in the vicinity of Double Island, River Styx, and Bard's Shoal, from July 1 to 6, inclusive, and from November 1 to December 24, inclusive. During the periods of work, 135 overhanging trees, and

1,900 cubic yards of brush were cut; 12 snags, and 7 sunken logs were removed from the channel; 331.5 cubic yards of rock were blasted, and 611.5 cubic yards of rock and 150 cubic yards of sand were removed from the channel.

PRESENT CONDITION OF THE RIVER.

The work done has resulted in giving a channel 60 feet wide and 4 feet deep at the assumed low-water stage, which, however, is probably too high, both at Double Island and Bard's Shoal, which were formerly the worst obstructions to navagation in the river below Hudson.

The narrow, crooked channels, rapid currents, and rocky bed of that portion of the river between Ellaville and Branford render navigation dangerous whenever the water is low.

From Branford to the mouth, the channel is in good condition. The channel through the Suwanee Basin is crooked, narrow in places, and has a least mean low water depth of but 3 or 4 feet.

FUTURE OPERATIONS.

The Suwanee River commerce comprises the movement of freight, farm produce, and naval stores to and from the railroads at Ellaville, New Branford, and Cedar Keys, and the rafting of cedar and other timber to the mills at the same towns. The roads are few and bad, and bulky produce can only be moved to advantage by water, so that an improvement to the stream which will make it continuously navigable is essential to the prosperity of the river valley. Excepting the traffic to and from Cedar Keys, there is no movement of freight out of the mouth of the river. This fact renders it unnecessary to extend the cuts previously made through the Suwanee Basin to the deep water of the gulf, and restricts the work under the project, which the present commercial status renders necessary, to the clearing of the river channel proper and the dredging of the oyster-bars from the Derrick Island Gap Pass at the mouth. After the improvement has been completed the channel can be kept clear with an estimated annual expenditure of $800.

The improvement of this river is greatly hampered by the carelessness of the saw-mill owners. Sawdust and slabs are allowed to find their way into the stream. Logs are run to the mills without being rafted. Many lodge on the rock ledges and form obstructions to navigation very difficult to remove. There seems to be no adequate protection afforded the United States against this misuse of the river.

The Suwanee River is in the collection district of St. Marks. Cedar Keys is the nearest port of entry; nearest fort is Fort Marion; nearest light-house, Cedar Keys Light.

Money statement..

July 1, 1889, amount available		$2,208.88
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$1,545.75	
July 1, 1890, outstanding liabilities	23.30	
		1,569.05
July 1, 1889, balance available		639.83
Amount appropriated by act of September 19, 1890		3,000.00
Amount available for fiscal year ending June 30, 1891		3,639.83
Amount (estimated) required for completion of existing project		24,158.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		10,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

Commerce of Suwanee River, Florida, during the year ending December 31, 1889.

Articles.	Quantity.	Estimated value.	Gross tonnage.	Increase due to improvement.
				Per cent.
Cotton.....bales..	1,680	$47,040.00	3,216	10
Fertilizers.....tons..	125	3,125.00	125	.....
Fruits.....boxes..	600	1,350.00	48	.....
Grain, flour, etc.....tons..	11,400	285,000.00	11,400	100
Hides.....number..	4,000	7,200.00	36	.....
Honey, sirup, etc.....gallons..	47,000	16,450.00	188	.....
Lumber:				
Rough logs.....B. M..	55,653,000	389,571.00	139,132	100
Sawed.....do...	37,358,400	373,583.33	93,396	75
Merchandise.....tons..	7,600	760,000.00	7,600	50
Ship stores, rosin.....barrels..	5,655	11,310.00	1,131	100
Vegetables.....boxes..	800	1,000.00	16	.....
Passengers.....number..	14,400	31,680.00	1,080	70
Cedar logs.....cubic feet..	795,492	23,201.85	1,193½	100
Turpentine.....barrels..	1,413	25,434.00	283	100
Cotton-seed.....tons..	532	7,980.00	532	50
Total.....	.....	1,983,925.18	259,376½	

No vessels plied this river during the year ending December 31, 1889, in a way to encourage commerce, excepting on occasional boat. All of the logs, lumber, and naval stores were rafted on the river.

Estimated percentage of total trade of neighborhood as given above carried by water, 60 per cent.; probable increase of trade were the improvement completed, 1,000 per cent.

Remarks.—The volume of trade on the Suwanee River has increased (in 1890) 200 per cent., owing to improvements in river. One steamer, of 190 tons, making tri-weekly trips, is unable to handle the freights at river points, and the early building of others is contemplated.

HENRY MARCOTTE.

P 12.

REMOVING SUNKEN VESSELS OR CRAFT OBSTRUCTING OR ENDANGERING NAVIGATION.

Work on the removal of the wreck, supposed to be the wreck of the German brig *Neva*, lying in Ward's Bank at the south of St. John's River, was continued by the contractor with many interruptions. Its final removal was reported on June 3, 1890. About 36 cords of log-wood were recovered.

It having been reported that portions of the wreck of the steamer *Maple Leaf*, off Mandarin, extended above the plane 18 feet below mean low water, to which it was reported to have been removed, a further examination of the site was made, aided by a diver. An old pile, covered with barnacles, was found at the site, probably the remains of a former beacon. An iron rod and a piece of timber, presumably a portion of the deck-house frame, were also found. All were removed and the site examined by the diver and swept over. No other obstructions could be discovered.

P 13.

PRELIMINARY EXAMINATION OF SARASOTA BAY, FLORIDA.

UNITED STATES ENGINEER OFFICE,
St. Augustine, Fla., February 8, 1889.

GENERAL: I have the honor to submit the following report on the preliminary examination of Sarasota Bay, Florida:

This bay, included between a range of sand keys, from 300 feet to 1 mile in width, and the mainland, lies on the west coast of Florida, immediately south of Tampa Bay. Its total length, including Little Sarasota Bay at the southern extremity, is about 33 miles. Its width varies from one-half mile to 3 miles in the main bay and from 300 feet to three-quarters of a mile in Little Sarasota Bay, while the channel between the two portions, called the Mangroves, is only about 50 feet wide and much obstructed by mangrove bushes, and shoals bare at low water. The depth in the main bay varies from 4 to 13 feet, with deeper narrow channels near the passes. The mean rise of tide is about 1.2 feet. Little Sarasota Bay is obstructed by shoals covered by from 1½ to 2 feet of water. The entrances to Sarasota Bay are (1) from Tampa Bay, one-half mile wide with available channel depth of 4 feet; (2) from the Gulf of Mexico long boat inlet, New Pass, and Big Sarasota Pass, 100, 150, and 400 yards wide, respectively, and with available channel depths varying from 5½ to 7 feet. The entrances to Little Sarasota Bay are the Mangroves, before mentioned, Little Sarasota Pass, and Casey's Pass, the last being at the southern extremity of the bay. The width of the passes is about 30 yards and the available depth from 2 to 4 feet.

A petition, signed by 315 persons, was presented to Congress at its last session, requesting the improvement of this bay from Tampa Bay to Casey's Pass.

An inquiry as to the nature of the improvement desired was answered by Mr. J. Hamilton Gillespie, of Sarasota. Mr. Gillespie stated that a continuous channel of from 4½ to 6 feet deep was desired through the entire length of Sarasota Bay as far as Casey's Pass; that the bays are navigated now by light-draught and steam boats, which are compelled to make trips at irregular intervals on account of the obstructions to the channels; that the present products of the region adjoining the bay comprised oranges, lemons, limes, bananas, pine-apples, corn, tobacco, honey, sugar, all kinds of vegetables, hogs, and cattle; other resources comprised turtles, fish and shell-fish, phosphates, and lime; that these products were carried in the small boats above mentioned or hauled over bad roads for 40 to 60 miles or less to the Manatee River; that the desired improvement would lead to a large increase in these products, and would lower the cost of transportation fully 100 per cent.; and that the lack of transportation facilities prevents the sale of the products now raised.

The examination of Sarasota Bay was made by Mr. D. B. Dunn, assistant engineer, whose detailed report is appended. Mr. Dunn confirms Mr. Gillespie's statements as to the products of the region and the losses caused by the lack of transportation facilities of that portion situated along and south of the "Mangrove" Channel between the two parts of the bays. Mr. Dunn states that the existing channel north of the Mangroves is all that is required for the present commerce, which seeks an outlet for rail and steam-boat transportation from points on Tampa Bay. Mr. Dunn recommends the improvement of the Mangrove

Channel and of those of Little Sarasota Bay. He estimates the cost of the improvement at $37,500, and the cost of a survey of the portion of the bay requiring improvement at $2,000. For the above reasons I have the honor to report that I deem the bay worthy of improvement.

Very respectfully, your obedient servant,

W. M. BLACK,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. D. B. DUNN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
St. Augustine, Fla., January 14, 1889.

CAPTAIN: I have the honor to report that, in accordance with instructions to make a preliminary examination of Sarasota Bay, I went by rail to Porto Tampa and thence by steamer *Kissimme* to Palma Sola, the nearest point reached by existing lines of travel, and on January 4 proceeded by sail-boat to make an examination of the bay from the bar to Casey's Pass, taking such notes and soundings as seemed commensurate with the purpose.

The main body of Sarasota Bay opens out of and runs southerly from Tampa Bay about 20 miles, with a varying width of from one-half to 3 miles, to what is known as "the Mangroves" where it narrows and continues with a varying width of from 200 feet to three-fourths of a mile, for a further distance of about 12 miles, being known as Little Sarasota Bay, and terminating in the outlet to the Gulf of Mexico known as Casey's Pass. The entire body runs parallel to the Gulf of Mexico, and is separated therefrom by a narrow chain of islands varying from 300 feet to 1 mile in width. On the bay proper steamers and light-draught vessels drawing 3½ to 4 feet of water ply successfully during the shipping season between Porto Tampa and the town of Sarasota, opposite Big Sarasota Pass, at all stages of the tide, which would seem to be all that was necessary for the commerce of the present or the near future, and the people along Little Sarasota Bay to Casey's Point express only a wish for such depths as would enable vessels of 3 feet draught to perform a like service.

Leaving Sarasota, the first and chief obstruction to this purpose is the series of Mangrove Islands, before referred to as "the Mangroves," about one-third of a mile across, with narrow, tortuous channels, almost dry at low tide, and with shallow approaches at either side. Other obstructions following in order are shallows at White Beach, north and south entrances to Little Sarasota Pass, Blackburn's Point, South Creek, Lyons Point, and a slight bar before entering the main channel at Casey's Pass. Within the limit of the proposed improvement the stretches between the obstructions have from 4 to 8 feet of water, and the obstructions, apart from the Mangroves, from 1 to 3 feet, while on the lower bay, between Sarasota and the bar, the prevailing depths are from 6 to 10 feet and over, with from 4 to 6 feet on the principal shoals and the bar. In the work required the Mangroves would aggregate two-thirds of the total outlay, presenting, as it does, an effective bar to navigation between the two bodies of water, and leaving to the settlers along Little Sarasota Bay, as their only alternative, the outside passage between Big and Little Sarasota bays.

Owing to the varied character of the shipments it is difficult to get any statistics of the present products of this region; the orange is the prime staple, and from Sarasota and points tributary the estimated shipment is 50,000 boxes, while southward to Casey's Pass 13,000 boxes find various uncertain outlets. The acreage of trees not yet in bearing is large and steadily increasing. Both shores are high, with fertile stretches of hummock lands, and limes, lemons, guavas, and the more tender fruits are grown successfully under the tempering influences of the bay. Fresh vegetables are plentiful at this season, and with proper shipping facilities would largely increase; fish and oysters are abundant.

I inclose letters from Mr. J. Hamilton Gillespie, of Sarasota, and Mr. Frank Higel, of Vienna, in the vicinity of Casey's Pass, both leading men in the business of their neighborhoods, to whom I am indebted for the statistics given.

A roughly estimated cost of the proposed improvement is $37,500. For a more accurate estimate in detail, a survey would be required, at an estimated cost of $2,000, and should it be deemed expedient to include the shoal portions of the lower bay and the bar in the survey, $3,000

Believing that the present population would be benefited, immigration induced, and trade stimulated by the proposed improvement, I respectfully recommend it.

Very respectfully, your obedient servant,

D. B. DUNN,
Assistant Engineer.

Capt. W. M. BLACK,
Corps of Engineers, U. S. A.

SURVEY OF SARASOTA BAY, FLORIDA.

UNITED STATES ENGINEER OFFICE,
St. Augustine, Fla., November 27, 1889.

GENERAL: I have the honor to submit the following report on the survey of Sarasota Bay, Florida, made in accordance with directions contained in the letter from your office dated April 1, 1889.

The field work of the survey was carried on during July and August, 1889, by a party under the charge of Mr. J. H. Bacon, assistant engineer. For information concerning the details of this work, I have the honor to invite attention to Mr. Bacon's report appended hereto. The survey included those portions of the bay in which the channel depth is less than 5 feet. The hydrography of other portions of the bay, as shown on the accompanying maps, is taken from the charts of the U. S. Coast and Geodetic Survey.

Sarasota Bay extends south from Tampa Bay along the west coast of Florida. Its length between Tampa Bay and Casey's Pass is 34 miles. It is separated from the Gulf of Mexico by a chain of low sandy keys, which vary in width from 300 feet to 1 mile.

There are five navigable entrances to the bay, one from Tampa Bay and four from the Gulf of Mexico. These are named in their order from north to south, Palma Sola or Sarasota Pass, Longboat Inlet, Big Sarasota Pass, Little Sarasota Pass, and Casey's Pass, and have available channel depths of 4.3 feet, 5 feet, 7 feet, 5.3 feet, and 3.5 feet, respectively. Between Big and Little Sarasota passes the bay is divided into two parts, named Big Sarasota Bay and Little Sarasota Bay, respectively, by a cluster of small islands covered with mangrove bushes and known as "the Mangroves." The channels between these islands are narrow and crooked and at places are bare at low water.

The localities where the survey was made are in Palma Sola Pass, at Long Bar south of Longboat Inlet, and between the north edge of the Mangroves and Casey's Pass.

Sarasota Bay is bordered by lands well suited for raising fruits and vegetables. The country roads are few and poor. The nearest railroads are at Port Tampa and St. Petersburgh, on the north side of Tampa Bay, where are also steam-ship lines to Gulf ports and Cuba.

The commercial needs of the country bordering on Sarasota Bay require an improvement of the bay, which will enable fruit and vegetables to be removed promptly from points on the bay to the railways and to the Gulf steam-ship lines at St. Petersburgh and Port Tampa. As this region is subject to heavy gales during the fruit-shipping season, steamers navigating Tampa Bay must have sufficient draught and power to permit their trips to be made in all kinds of weather. For this reason a channel depth of at least 5 feet is required. This depth can be attained at small expense through Big Sarasota Bay, by dredging across the bars on Palma Sola Pass and at Long Bar.

The present commercial interests of the country bordering on Little

Sarasota Bay are not sufficient to justify at this time the expenditure which would be required to continue this 5-foot channel as far as Casey's Pass. A 3-foot channel can be made for moderate cost, which would enable the farmers to carry their fruits in flats or sail-boats to Little Sarasota Pass, or to Sarasota, where connection can be made with the Tampa Bay steamers.

As the obstructions are generally oyster bars, and as a good tidal circulation would be established were they removed, there is a fair chance of permanence for dredged channels without special works of protection.

I therefore have the honor to recommend that a channel 5 feet deep and 100 feet wide be opened through Sarasota Bay from Tampa Bay to Sarasota, and 3 feet deep and 75 feet wide from Sarasota to Casey's Pass. The estimated cost of this work is $37,500.

The products of this country include palmetto, agave, and banana fibers, honey, sugar, sirup, oranges, lemons, limes, bananas, pine-apples, vegetables, lumber, fish, oysters, and cattle. Owing to the absence of regular and economical facilities for transportation but few of these products are exported. Trade is limited to the actual necessities of the population.

The region is healthy and pleasant, and would be developed rapidly were it possible to have regular and certain communication with the shipping ports.

Very respectfully, your obedient servant,

W. M. BLACK,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. J. H. BACON, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
St. Augustine, Fla., November 15, 1889.

CAPTAIN: I have the honor to submit the following report on the survey of Sarasota Bay, Florida:

Sarasota Bay is a tidal estuary on the west coast of Florida, extending from the lower end of Tampa Bay to Casey's Pass, a distance of about 34 miles. It is separated from the Gulf of Mexico by a chain of narrow keys, varying in width from 300 feet to 1 mile. The upper portion, from Tampa Bay to the "Mangroves," is called Big Sarasota Bay, and the lower portion, between the "Mangroves" and Casey's Pass, is known as Little Sarasota Bay. There are five navigable entrances to the bay, one from Tampa Bay and four from the Gulf of Mexico. These are (1) Palma Sola (or Sarasota) Pass, having an available mean low-water depth of 4.3 feet; (2) Long-boat Inlet, with a depth of 5 feet; (3) Big Sarasota Pass, with a depth of 7 feet; (4) Little Sarasota Pass, with a depth of 5.3 feet; and (5) Casey's Pass, with a depth of 3.5 feet. The present available mean low-water depth through Big Sarasota Bay is 3.5 feet, while that through Little Sarasota Bay is zero, navigation through the "Mangroves" being practically suspended during low water.

On July 16 and 17, 1889, an examination of the bay from Palma Sola Pass to Casey's Pass was made by the officer in charge. From this examination it was found that there was a continuous channel 5 feet in depth at mean low water through the entire length of Big Sarasota Bay, except at two points, viz: Palma Sola Pass, the entrance from Tampa Bay, and at Long Bar; the available mean low-water depth at these places was subsequently found to be 4.3 feet and 3.5 feet, respectively. Numerous obstructions were found in Little Sarasota Bay. As a result of this examination I was directed by the officer in charge to make such a survey as would enable me to estimate the cost of dredging a continuous 5-foot channel at mean low water from Tampa Bay to Casey's Pass, relying on the Coast Survey charts for all supplementary data.

On July 19, 1889, I began the field work of the survey, assisted by Messrs. A. C. Harper, J. L. Brownlee, and Otto Bie. The work was finished on August 7. The method used was as follows:

A transit was set up in a favorable position and all necessary soundings within the range of the instrument were taken, and a sufficient number of points on each line of soundings were located by means of stadia measurements. A new station was then located and the same operation repeated. The shallow water and sluggish current of the lower bay rendered this method quite rapid and accurate. On plotting the work it was found to agree closely with that of the Coast Survey.

The survey extended from Post-Office Point, just below the town of Sarasota, through Little Sarasota Bay to Casey's Pass. Detached surveys were made of Palma Sola Pass and Long Bar. Tidal bench-marks were established at Long-boat Inlet, the "Mangroves," and Little Sarasota Pass, and were referred to the U. S. Coast Survey bench-mark at "Hanson's." The mean range of tide determined by the Coast Survey by five months' observations is 1.25 feet.

Borings to rock were taken frequently. The average depth of rock was found to be about 8 feet below mean low water. No rock was found in the proposed channel at depth of less than 5 feet below low water, except at "Minnie's Ford," where it cropped out in spots at a depth of 4.5 feet. The material to be excavated consists mainly of hard sand, overlaid in places with oyster shell.

A map on a scale of $\frac{1}{5000}$ and one* on a scale of $\frac{1}{20000}$ have been prepared from the notes of this survey and from the original charts of the U. S. Coast Survey, and are submitted with this report.

Estimates for a continuous channel from Tampa Bay to Casey's Pass for widths of 100 feet and 50 feet and for depths of 5 feet and 3 feet are herewith submitted. In these estimates 1 foot extra cutting is allowed for back filling and 15 per cent. for increase of bulk. The excavated material can be deposited alongside the cut in Little Sarasota Bay, as the current there is very slight and no danger from high waves is to be apprehended. At Palma Sola Pass and Long Bar the haul need not be more than 2 miles.

Very respectfully, your obedient servant,

J. H. BACON,
Assistant Engineer.

Capt. W. M. BLACK,
Corps of Engineers, U. S. A.

Estimates for a depth of 5 feet at mean low water.

Locations.	Present available depth.	Length of cut.	100 feet wide.		50 feet wide.	
			Quantity.	Amount.	Quantity.	Amount.
	Feet.	*Feet.*	*Cub. yds.*		*Cub. yds.*	
Palma Sola Pass	4.3	1,800	9,360	$2,340.00	4,500	$1,125.00
Long Bar	3.5	3,600	26,100	6,525.00	12,000	3,000.00
Mangroves to Minnie's Ford	.....	.....	*680	4,400.00	†400	2,000.00
		11,130	174,000	43,500.00	58,700	14,675.00
White Beach:						
Upper	1.3	425	5,980	1,495.00	2,900	725.00
Lower	4.0	560	3,130	782.50	1,500	375.00
North Creek	3.0	1,350	21,740	5,435.00	7,240	1,810.00
Little Sarasota Pass to Casey's Pass	1.2	27,330	324,180	81,045.00	111,200	27,800.00
Total	.....	46,195	564,490	145,522.50	198,040	51,510.00
Engineering and contingencies, 15 per cent	.....	.....	.....	21,828.37	.....	7,726.50
Grand total	.....	.....	.....	167,350.87	.....	59,236.50

* Omitted; printed in House Ex. Doc. No. 61, Fifty-first Congress, first session.
† Rock at $5 per cubic yard; other material, 25 cents per cubic yard.

For a depth of 3 feet at mean low water (no rock).

Location.	Present available depth.	Length of cut.	100 feet wide.		50 feet wide.	
			Quantity.	Amount.	Quantity.	Amount.
	Feet.	*Feet.*	*Cub. yds.*		*Cub. yds.*	
Mangroves to Minnie's Ford	.....	7,620	80,661	$20,165.25	26,880	$6,720.00
White Beach, Upper	1.3	370	2,000	500.00	1,000	250.00
Blackburn's Point	2.4	400	1,748	437.00	800	200.00
South Creek:						
Upper	1.5	1,500	11,477	2,869.25	4,800	1,200.00
Lower	1.2	1,060	8,728	2,182.00	4,060	1,015.00
Blackburn, jr.:						
Upper	2.5	1,000	4,140	1,035.00	2,000	500.00
Lower	1.2	400	4,762	1,190.50	2,200	550.00
Lyon s Bay	2.0	120	1,012	253.00	500	125.00
Casey's Pass	1.5	300	7,650	1,914.75	3,800	950.00
Total	.....	12,770	122,187	30,546.75	46,040	11,510.00
Engineering and contingencies, 15 per cent	.....	.....	.....	4,582.01	.....	1,726.50
Grand total	.....	.....	.....	35,128.76	.....	13,236.50

Estimate No 2, Sarasota Bay, Florida.

Location.	Present available depth.	Length of cut.	Width of cut.	Depth of cut.	Cubic. yards.	Amount.
	Feet.	*Feet.*	*Feet.*	*Feet.*		
Palma Sola Pass	4.3	2,000	100	5.0	15,700	$3,925.00
Long Bar	3.5	3,600	100	5.0	26,100	6,525.00
Mangroves to Minnie's Ford	.....	7,620	75	3.0	60,400	15,100.00
White Beach, Upper	1.3	370	75	3.0	1,500	375.00
Blackburn's Point	2.4	400	75	3.0	1,300	325.00
South Creek:						
Upper	1.5	1,500	75	3.0	7,650	1,912.50
Lower	1.2	1,060	75	3.0	6,540	1,635 00
Blackburn, jr.:						
Upper	2.5	1,000	75	3.0	3,100	775.00
Lower	1.2	400	75	3.0	3,500	875.00
Lyon's Bay	2.0	120	75	3.0	780	195.00
Casey's Pass	1.5	300	75	3.0	3,800	950.00
Total	.....	48,195	.....	.....	130,370	32,592.50
Engineering and contingencies, 15 per cent	.....	.....	.....	.....	.....	4,888.87
Grand total	.....	.....	.....	.....	.....	37,481.37

APPENDIX Q.

IMPROVEMENT OF CERTAIN RIVERS IN THE STATES OF FLORIDA, GEORGIA, AND ALABAMA, OF APALACHICOLA BAY, AND OF HARBOR AT PENSACOLA, FLORIDA.

REPORT OF CAPTAIN PHILIP M. PRICE, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1890, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Apalachicola River, Florida.
2. Apalachicola Bay, Florida.
3. La Grange Bayou, Florida.
4. Pensacola Harbor, Florida.
5. Choctawhatchee River, Florida and Alabama.
6. Escambia and Conecuh rivers, Florida and Alabama.
7. Flint River, Georgia.
8. Coosa River, Georgia and Alabama.
9. Chattahoochee River, Georgia and Alabama.
10. Tallapoosa River, Alabama.
11. Cahaba River, Alabama.
12. Alabama River, Alabama.
13. Operating and care of canals and other works of navigation on the Coosa River, Georgia and Alabama.

EXAMINATION AND SURVEY.

14. Coosa River, Alabama, from the rapids at Wetumpka, to connect with the improvements already completed on said river above the Ten Islands.

UNITED STATES ENGINEER OFFICE,
Montgomery, Ala., July 9, 1890.

GENERAL: I have the honor to forward herewith annual reports for the fiscal year ending June 30, 1890, upon the works under my charge.

* * * * * * *

Very respectfully, your obedient servant,

PHILIP M. PRICE,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

Q 1.

IMPROVEMENT OF APALACHICOLA RIVER, FLORIDA.

The survey for this improvement was made between November, 1872, and February, 1873, and resulted in the adoption of a project which contemplated securing a channel 100 feet wide and 6 feet deep from its mouth up to the river Styx; through that river to Moccasin Slough,

through the slough to the Apalachicola River again, and up it to its head, by the removal of snags and straightening and widening the channel at Moccasin Slough, at an estimated cost of $80,333. The river is now in a good navigable condition, except at Moccasin Slough and the Upper and Lower Elbows. The cut at Moccasin Slough was made narrow and shallow, with the expectation that the stream itself would widen and deepen it, but the bottom and banks, which consist of heavy clay, do not readily yield to the action of the current, and some further excavation of the banks is necessary to make navigation safe. At the "Elbows" the sharp bends and large whirlpool eddies render navigation difficult and dangerous. At these points the channel should be widened.

It is estimated that the further improvements needed at Moccasin Slough and the "Elbows" can be made for $5,000. The maintenance of the improvement, as it now stands, requires an annual appropriation of $2,000 for the removal of the accumulation of snags and overhanging trees. This work is done by using the snag-boat belonging to the Chattahoochee River at such times as it can be spared from that river, and charging its expenses during such time to the Apalachicola River.

APPROPRIATIONS.

June 23, 1874	$10,000
March 3, 1875	10,000
June 18, 1878	8,000
March 3, 1879	5,000
June 14, 1880	2,000
March 3, 1881	1,500
August 2, 1882	2,000
July 5, 1884	1,000
August 5, 1886	1,000
August 11, 1888	2,000
Total	42,500

WORK DONE DURING THE PAST FISCAL YEAR.

In November and December, 1889, the snag-boat *Chattahoochee* was employed upon this improvement. Assistant Engineer Thomas Robinson, who is in local charge of the river, reports that with an average force of 18 men, working 33 days, 12 projecting stumps were cut level with the banks, 1,234 overhanging trees were felled and cut up, and 270 drift logs and trees, 91 sunken snags, and 3 old piles were removed from the channel.

It is proposed to expend the small available balance, and the appropriation asked for, in the continuance and maintenance of this improvement.

The Apalachicola River is in the collection district of Apalachicola, Fla., which is the nearest port of entry. The nearest light-house, Cape St. George Light; the nearest fort, defenses of Pensacola Harbor, Florida.

Money statement.

July 1, 1889, amount available	$1,758.41
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	1,437.62
July 1, 1890, balance available	320.79
Amount appropriated by act of September 19, 1890	2,000.00
Amount available for fiscal year ending June 30, 1891	2,320.79
Amount that can be profitably expended in fiscal year ending June 30, 1892 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	7,000.00

For commercial statistics, reference is made to the annual reports upon the improvements of Apalachicola Bay, Florida, Chattahoochee River, Georgia and Alabama, and Flint River, Georgia. The steamers which run on the Chattahoochee and Lower Flint rivers, also run on the Apalachicola River, and it is impossible to submit separate statements of the commercial statistics for each river.

Q 2.

IMPROVEMENT OF APALACHICOLA BAY, FLORIDA.

PLAN OF IMPROVEMENT.

Under an act of Congress approved July 11, 1870, an examination and partial survey at the mouth of Apalachicola River, with a view to its improvement, was made in 1871, and a further examination was made in 1879, for the purpose of ascertaining the changes which had taken place since 1871. The minimum depth of water over the bar at the mouth of the river was 3½ feet.

These examinations resulted in the adoption of a plan of improvement which contemplated the dredging of a straight channel through the bar at the mouth of the river to a depth of 11 feet and a width of 100 feet, to be afterwards increased to 200 feet if the first cut should produce results that would warrant it. During the progress of the work it has been urged that sufficient appropriations should be made to complete the cut through the bar. It was thought that a continuous dredged channel of the approved width and depth might be to some extent self-sustaining, but funds have never been available for dredging the channel called for by the approved project.

The original estimate of the cost of the improvement was $100,000. More or less dredging in the channel was done annually from 1881 to 1885, but on account of the limited appropriations the dredged cut never exceeded 75 feet in width and 9½ feet in depth. This cut gradually filled up, partly with sediment brought down by the river and partly with material washed in from the sides of the cut by the currents produced by the tides and the prevailing easterly winds. In 1887 a channel 60 feet wide and 9 feet deep was redredged for a length of 3,635 feet. An examination made in March, 1889, showed that the channel had again shoaled to a least depth of 4 feet at mean low water.

APPROPRIATIONS.

June 14, 1880	$10,000
March 3, 1881	10,000
August 2, 1882	25,000
July 5, 1884	10,000
August 5, 1886	12,000
August 11, 1888	20,000
Total	87,000

WORK DONE DURING THE PAST FISCAL YEAR.

On June 12, 1889, a contract with the Alabama Dredging and Jetty Company of Mobile, Ala., was approved for dredging a channel 8 feet deep and of as great a width—not exceeding 100 feet—as the funds available ($19,671.77) would permit of.

Under their contract the contractors should have begun work on or before, July 15, 1889, and completed their contract by December 15,

1889, but for various reasons extensions of time were granted by authority of the Chief of Engineers. Actual dredging was begun on November 27, 1889, and completed on May 10, 1890. Sixty-five thousand five hundred and forty-seven cubic yards of mud and sand were removed from the channel. The dredged cut is 8 feet deep and varies in width from 80 to 90 feet. The cut was begun 750 feet south of the outer beacon, and carried to a point 250 feet north of the inner beacon, a total length of 6,000 feet. The accompanying map shows the location of the dredged channel.

When the tide would permit the tug-boats have been in the habit of leaving the channel inside of the outer beacon. As a result of this, sand and mud are thrown by the screws from the side into the cut. To prevent this, under the approval of the Chief of Engineers, a row of 15 pile clusters of 3 piles each had been driven between the outer beacon, and the old pile cluster No. 2, as shown on the accompanying map.

During the past year Assistant Engineer Thomas Robinson has had local charge of this improvement, with Mr. Saint-Clair Hartman as inspector of dredging.

The subjoined estimate of cost of completion of existing project ($60,000) is the probable cost of completing the dredged cut through the bar to the approved with of 100 feet and depth of 11 feet.

Money statement.

July 1, 1889, amount available		$19,675.52
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$17,684.90	
July 1, 1890, outstanding liabilities	401.50	
		18,086.40
July 1, 1890, balance available		1,589.12
Amount appropriated by act of September 19, 1890		20,000.00
Amount available for fiscal year ending June 30, 1891		21,589.12
Amount (estimated) required for completion of existing project		40,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		40,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

COMMERCIAL STATISTICS.

Statement of the commerce of the port of Apalachicola, Fla., from May 1, 1889, to April 30, 1890.

Custom-house receipts:		
Duties on imports		$673.80
Tonnage dues		1,606.24
Official fees		426.37
Total receipts		2,706.41
Number of vessels entered, 115	tonnage	49,338
Number of vessels cleared, 109	do	48,433
Number of vessels employed in the traffic of Apalachicola Bay		85
Number of superficial feet of timber and lumber exported		36,966,401
Estimated number of vessels and river steamers arrived and departed		675
Estimated tonnage of above vessels		86,000
Value of exports to foreign ports		$178,041
Value of exports to coastwise ports		441,608
Total value of exports		619,649

APALACHICOLA BAY

PLAN SHOWING CHANNEL DREDGED. NOV. 1889. – MAY 1890

(CONTRACT OF ALABAMA DREDGING & JETTY CO.)

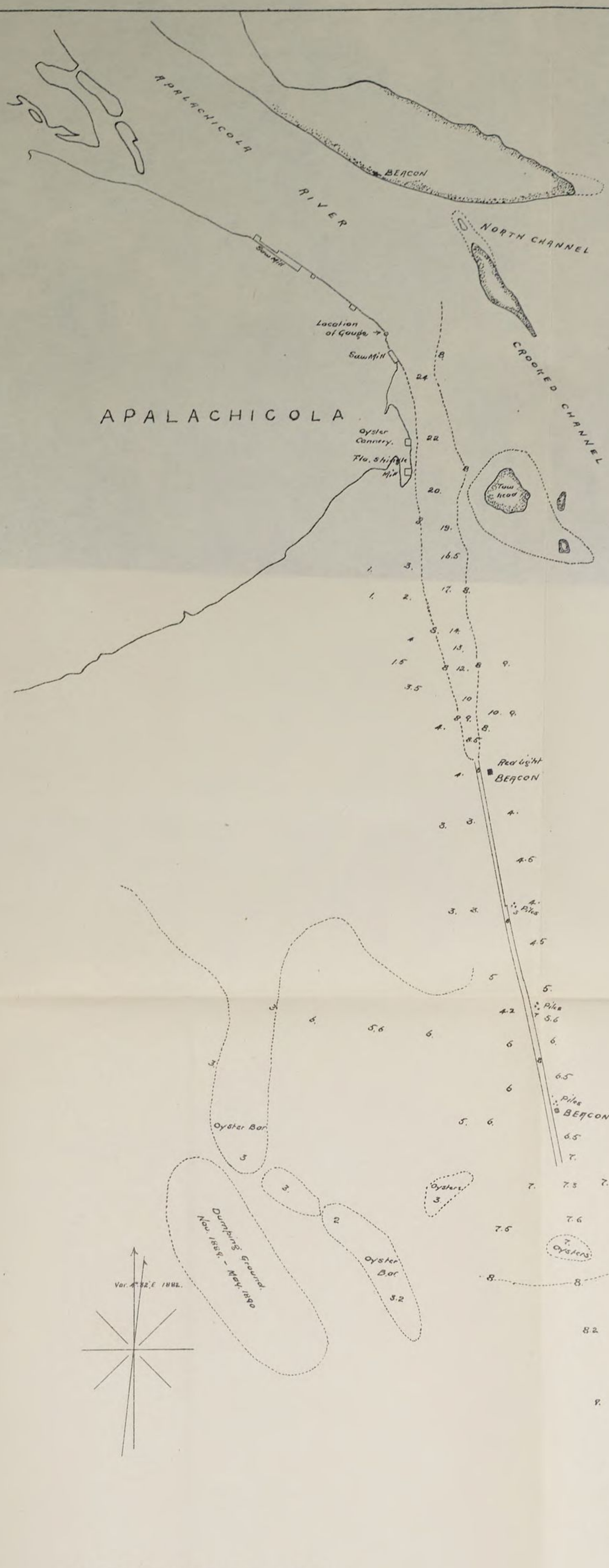
SHORE LINE from Coast Survey Chart No. 183.

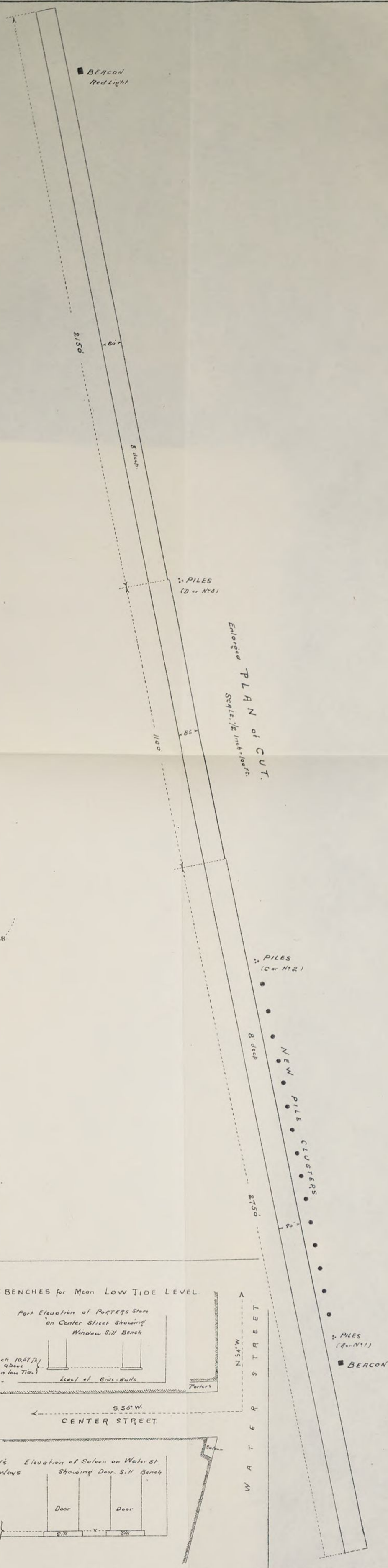
SOUNDINGS &c. &c. by Asst. Engr. Thos. Robinson May 1890

SCALE, 2000 feet to 1 inch.

MADE UNDER THE DIRECTION OF
CAPT. PHILIP M. PRICE
CORPS OF ENGINEERS. U.S.A.

U.S. Engineer Office
Montgomery, Ala. June 30th 1890.
To accompany Annual Report for 1890.
Philip M. Price.
Captain of Engineers

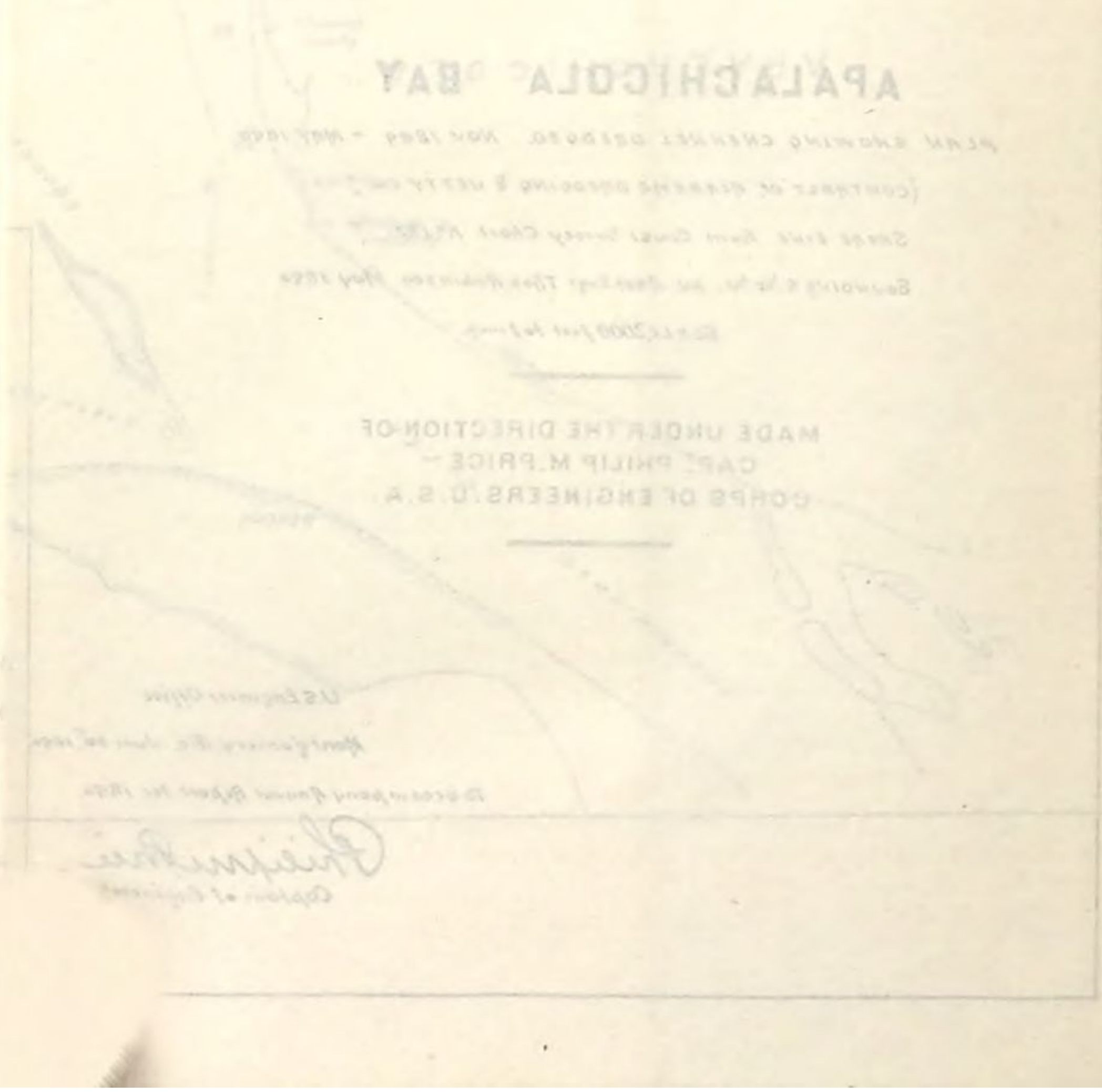




Enlarged PLAN of CUT.
SCALE, 1/2 inch = 100 ft.

PLAN of BENCHES for Mean LOW TIDE LEVEL

Photo-Lith. by A. HOEN & CO., Balto., Md.



Value of imports from foreign ports	$772
Value of imports from coastwise ports	76,500
Total value of imports	77,272
Total value of imports and exports	696,921
Estimated value of exports to coastwise ports by sail-vessels and river steamers which do not enter at or clear from the custom-house	650,000
Estimated value of imports by sail-vessels and river steamers from coastwise ports which do not enter at or clear from the custom-house	1,200,000

There are six saw-mills, which can turn out 360,000 superficial feet of lumber per day; two oyster-canning factories, with a capacity of 40,000 cans per day; one fish-packing establishment, which packs up about 5,000 barrels of salted and pickled fish per annum; one ice factory, making 5 tons of ice per day; one planing mill, with a capacity of 15,000 superficial feet per day; and one shingle mill, with a capacity of 150,000 shingles per day.

All the above enterprises expect to do double the amount of business during the present year, as the demand for all the above-mentioned products is unlimited.

A. J. MURAT,
Collector of Customs (Special Deputy).

Q 3.

IMPROVEMENT OF LA GRANGE BAYOU, FLORIDA.

PLAN OF IMPROVEMENT.

The La Grange Bayou extends about 2 miles in a northeasterly direction from the north side, and near the head of the Choctawhatchee Bay, and into it flows Cedar Creek, a deep stream from 90 to 160 feet wide, on which is situated the town of Freeport, 1½ miles above the bayou.

The plan of improvement adopted was made pursuant to an examination of this bayou in 1881, under an act of Congress approved March 3, 1881, and contemplates the deepening of the channel through the bayou, so as to admit the passage of vessels drawing 4½ feet at mean low water, the work to be done by dredging.

The original estimate of the cost of this improvement is $19,994.30.

Up to June 30, 1888, there had been expended on this work the sum of $2,000 allotted from the appropriation of $20,000 made by an act approved August 2, 1882, for the improvement of the Choctawhatchee River, Florida. The result was the securing of a channel 5 feet deep at mean low water.

The act of August 5, 1886, appropriated $2,000 for this improvement. It was not thought that so small a sum could be profitably expended, and it was decided to hold it until a further sum was appropriated.

The act of August 11, 1888, appropriated $3,000 to complete the improvement of La Grange Bayou, including Holmes River, as far as the town of Vernon, an estimated distance of 28 miles. In February, 1889, an examination and partial survey of both La Grange Bayou and Holmes River were made by Assistant Engineer W. A. Gould for the purpose of determining the amount of excavation necessary to complete the improvement of La Grange Bayou, and the cost of clearing out Holmes River. It was found that the improvement of La Grange Bayou, to admit the passage of vessels drawing 4½ feet at mean low water, would require the removal of 24,444 cubic yards of material, which, at 50 cents per yard, would cost $12,222, and that the cost of clearing the snags, logs, and overhanging trees from Holmes River would be $3,000, exclu-

sive of plant. On the presentation of these facts to the honorable Secretary of War by the Chief of Engineers, it was directed that no further expenditure of funds should be made from these appropriations.

APPROPRIATIONS.

August 2, 1882	$2,000
August 5, 1886	2,000
August 11, 1888	3,000
Total	7,000

Previously to the building of the Pensacola and Atlantic Railroad the town of Freeport was the port of entry for a large portion of country surrounding it, and contained seven flourishing stores, and considerable commerce passed through La Grange Bayou; but since the completion of the railroad most of the territory formerly supplied through Freeport now draws its supplies by way of the railroad and the Choctawhatchee River. The town of Freeport, at the time of the last examination, contained but one store, and its commerce was carried on by one small schooner, which made irregular trips between it and Pensacola. Holmes River is a wide and deep stream, and passes through a rapidly-developing country, to which its opening to navigation would be a great benefit. It is now so obstructed by snags, logs, and overhanging trees that steamers can not pass up it. It could most economically be cleared of these obstructions by using the log-boat belonging to the Choctawhatchee River, as this boat could be used on Holmes River during the high-water season of the Choctawhatchee, when it would otherwise be laid up. To adapt the boat to this use, however, it should be provided with propelling power, which it has not now. This would also increase its usefulness for work on the Choctawhatchee River, and could be effected at a cost of $2,500. I therefore recommend, in case it is decided to improve Holmes River, that the appropriation be made for that purpose only, and that its improvement be disassociated from that of La Grange Bayou, with which it has no connection whatever. Holmes River is an affluent of the Choctawhatchee River.

An annual appropriation of $1,000 would probably be required to maintain the improvement of Holmes River.

Money statement.

July 1, 1889, amount available	$4,839.20
July 1, 1890, balance available	4,839.20
Amount appropriated by act of September 19, 1890	3,000.00
Amount available for fiscal year ending June 30, 1891	7,839.20
Amount that can be profitably expended in fiscal year ending June 30, 1892, for improving Holmes River only	5,500.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

The census for 1880 gives for the counties bordering upon La Grange Bayou, within the limits of the improvement, a total assessed valuation of real and personal property amounting to $244,506, and a total taxation of $3,362.

The building of the Pensacola and Atlantic Railroad, about 18 miles to the north of Freeport, has so diminished the commerce of the latter, which formerly passed through La Grange Bayou, that Freeport now contains but one store, and that but one sailing craft now uses the bayou on irregular trips between Freeport and Pensacola. It has not been reported that this boat experiences any difficulty in passing through the bayou.

Q 4.

IMPROVEMENT OF HARBOR AT PENSACOLA, FLORIDA.

PLAN OF IMPROVEMENT.

Under an act of Congress approved June 18, 1878, the improvement was commenced by the removal in 1879–'80, of certain wrecks forming obstructions to navigation. In 1879 an examination and partial survey was made for the purpose of ascertaining the extent and probable cause of the shoaling of the main ship-channel at a point known as the "Inner Bar." In 1881 the present plan of improvement was adopted in conformity to the recommendations of the Board of Engineers for Fortifications and for River and Harbor Improvements. The project provides for the construction of jetties near the site of Fort McRee to prevent further abrasion of the shore-line and consequent changes in the tidal currents, and to preserve the site for defensive works, and for the dredging of a channel 24 feet deep and 300 feet wide across the inner bar.

The ultimate cost of this improvement is not estimated in the original project, which assumes that it will exceed $150,000. The annual appropriations have not been sufficient to enable this project to be carried to a rapid completion, as was originally contemplated. In consequence, the channel has never been dredged to a greater width than 120 feet, and a very large proportion of the appropriations made has been expended in redredging and in repairing and rebuilding the jetties. Strong tidal currents cross the inner bar almost at right angles, and it is not believed that a permanent improvement can be effected by dredging. The work of shore protection, as completed during the present year, is believed to be practically permanent, but it may require extension. No dredging has been done since 1886, at which time the dredged channel over the inner bar was reported as having a depth of 24 feet and width of 120 feet at mean low water. This channel has since been gradually shoaling. The original project provided for no improvement of the outer bar to correspond with that of the inner bar.

By letter from office of the Chief of Engineers, dated March 29, 1890, I was directed to submit a report in regard to the condition of the outer bar, with an estimate of the cost of obtaining the required depth on it by dredging. An examination of both the inner and outer bars was made early in April, 1890, which showed that the least depth on the outer bar was then 22.1 feet at mean low water, and on the inner bar 19.6 feet. In my report of this examination, dated April 16, 1890, it was estimated that an appropriation of $106,446 would be required to dredge a channel 24 feet deep and 300 feet wide through both the inner and outer bars. In the money statement below $81,446 is therefore given as the amount required for the completion of the existing project, and as the amount that can be profitably expended during the next fiscal year. In order to accomplish the object desired the entire amount should be appropriated in one sum.

APPROPRIATIONS.

June 18, 1878	$20,000
March 3, 1879	10,000
June 14, 1880	40,000
March 3, 1881	20,000
August 2, 1882	50,000
July 5, 1884	55,000
August 5, 1886	20,000
August 11, 1888	35,000
Total	250,000

SUMMARY OF OPERATIONS TO DATE.

The average annual appropriation has thus been $20,833.33⅓. With this amount it has never been practicable to complete the dredging of the prescribed channel through the inner bar. Partial dredging was done at various times between the years 1882 and 1886. At the conclusion of the dredging in 1886 it was reported that the channel over the inner bar was 24 feet deep and 120 feet wide. No dredging has since been done and in April, 1890, the least depth at mean low water on the inner bar was 19.6 feet, and on the outer bar 22.1 feet.

The work of preventing further abrasion of the shore-line near Fort McRee, was begun in 1881, and continued until May, 1890, whenever funds were available for the purpose. The work was at first of a tentative character. Two jetties, having lengths of 360 and 220 feet, respectively, were built nearly perpendicular to the shore-line north of Fort McRee. The jetties were constructed of close piling filled with alternate layers of brush and stone with side slopes of the same construction. These jetties were exposed to the action of violent storms from the Gulf, the waves which break upon the shore having great destructive power. They were also exposed to the attacks of the teredo, which are very destructive in these waters. From these causes more than 75 per cent. of the work had been destroyed previous to 1888, notwithstanding that much repair and auxiliary work had been done to preserve them. As their usefulness in preserving the shore-line had been demonstrated it was then decided to rebuild them in a substantial manner, by covering what remained of them with a coping and side slopes of heavy stone and concrete blocks. This work was completed as far as at present appears to be necessary, in April 1890. Two thousand six hundred and eighty-one tons of stone (granite) have been used; the larger stone weighing from 1 to 4 tons. Three sizes of concrete blocks—3 by 3 by 5, 3 by 3 by 10, and 4 by 4 by 6 feet—have been used, weighing, respectively, about 3, 6, and 6¾ tons. In all, 402 cubic yards of blocks have been used. Each jetty has been coped with a monolithic mass of concrete, built in place. The method of construction, dimensions, and relative positions of the completed jetties are shown on the accompanying tracing. The past spring has been unusually stormy, and the reconstructed jetties have been exposed to several unusually severe storms, which they have withstood perfectly. No settlement or derangement of the work whatever has been apparent.

When the improvement was begun the beach-line had receded to the walls of Fort McRee, and the greater part of the fort had been undermined and destroyed. In this vicinity the beach-line is now advanced 131 feet. South of Fort McRee, the beach-line is now protected by the ruins of the old water battery, which was built of brick laid in cement. No necessity for the further extension of the shore protection by jetties, is now apparent.

In view of the fact that the balance remaining after the completion of the jetties would not be sufficient to undertake any dredging, and that an accurate survey, which would include detailed observations, to determine the directions and velocities of the surface and bottom currents, would be required in order to determine the proper location of a channel to be dredged under future appropriations or for the proper application of any appropriations which might in future be made for a permanent improvement of the harbor, I requested authority, by letter of March 24, 1890, to expend the necessary amount from this balance in making such survey. This authority having been granted, the survey

was begun in the latter part of April, 1890, and has since been continued whenever the condition of the weather would permit. It has so far been very much delayed by stormy weather, which made the sea too rough for taking accurate soundings.

WORK DONE DURING PAST FISCAL YEAR.

Assistant Engineer J. E. Turtle, in local charge of the improvement, reports as follows:

At the beginning of the fiscal year the force was employed in the construction of concrete blocks and in placing the large loose stone in north jetty.

During the month of July the estimated amount of concrete blocks for repairs to north and south jetties having been made, this portion of the work was suspended and the rebuilding of the north jetty pushed as rapidly as the weather and plant on hand would permit. On January 25, 1890, the last of the concrete blocks were placed in the north jetty, and the work of repairing the south, or Jetty A, commenced.

While work was being performed the weather was constantly unfavorable, and the work unusually and necessarily expensive. This jetty was completed on April 16, 1890, and immediately thereafter the housing of all property commenced. Derricks and machinery have been properly cleaned and housed.

The testing of cement has been carried on during the year without interruption, the bricquettes broken to date varying in age from one week to one year.

The survey ordered by your letter of April 1, to be commenced after the completion of the south jetty, could not be commenced, owing to stormy weather, before April 21. Since that date it has been continued whenever it was possible to do so.

GENERAL DESCRIPTION OF REPAIRS TO NORTH JETTY.

This jetty as originally built consisted of close piling filled with alternate layers of brush and stone, the slope being similar in construction. Storms and the teredo destroyed about 90 per cent. of this previous to 1888.

A plan was approved to repair this in a more substantial manner and revised by yourself in August, 1889. From the shore the new plan called for a structure to be built with the large irregular stones purchased by contract, and having suitable slopes; and when these stones were exhausted to continue the structure to the 24-foot curve with concrete blocks. The concrete blocks to be 3 by 3 by 10 feet, 3 by 3 by 5 feet, and 4 by 4 by 6 feet; the seaward slope to be not less than 1½ to 1. The small stone purchased by contract were to be kept below 12 feet at ordinary high water, and were to form an apron directly in front of the structure, and to be protected from rolling by wave action by having concrete blocks placed on the center-line of this apron, the entire structure to be capped with a concrete coping, and the coping to be also carried 39 feet inshore to better secure this end.

In accordance with this plan, this jetty has been completed. (See drawing herewith submitted).

OPERATIONS.

After the last of the irregular stones were placed, the coping was then put on, having an elevation of 5 feet 7 inches above mean low water. Upon this the track was placed, and the first of the concrete blocks, 3 by 3 by 10 feet was placed at the foot of the irregular slope. This and the other blocks placed in the core have a foundation upon sacks filled with cement placed by a diver (Mr. Louis G. Johnson, the suboverseer). These blocks were also placed by the same diver, and were transported and handled by means of a movable derrick built upon trucks, having the necessary counterpoise at the after end and an overhang of 12 feet. When 12 running feet of jetty were thus built up to mean low water, blocking for the track was placed upon this 12 feet and the concrete blocks advanced 12 feet more. A timber box, or mould, for the coping was then built on this 24 feet of concrete blocks, and filled with concrete. When the coping was sufficiently hard to admit of transporting material over it, the jetty was similarly advanced. The concrete for coping was mixed with the malaxator, and carried in dump-boxes on cars to the required locality; these cars, as well as the movable derrick with its load, were hauled by ropes leading to the drum of the hoisting engine. One course of blocks up to mean low water, was placed with a derrick on the seaward slope, and was fairly bedded. The remaining blocks on this slope were placed at random, being lowered by a derrick from a barge; one layer of large blocks, placed also with a derrick, protects the northern

berme. Twenty-three feet of the apron, directly in front of the jetty, are also covered with large blocks, which were also lowered into place from a derrick. This jetty, as completed, is 322½ feet in length.

GENERAL DESCRIPTION OF REPAIRS TO SOUTH JETTY.

This jetty, as originally built, was similar to the North Jetty above described, and deteriorated in the same manner. One hundred and four running feet of this has been repaired by placing concrete blocks on the remains of the original work, and capping with a concrete coping.

The outer end of this coping is finished, arrow-pointed, to deflect the racing waves as a protection against displacement of the small foundation stone.

During October and November, 1889, quarters for the sub-overseer were built; this consists of two rooms each 12 by 12 feet, and kitchen 12 by 7 feet.

GENERAL REPAIRS.

During the year there consisted in repairs to large shed, placing a sill under the south side, and replacing old wooden foundations with brick piers; repairs to boiler, and repairs to skiffs.

TESTING CEMENT.

The tests applied to cement are for fineness and tensile strength, both with neat cement and with mixtures of different proportions of sand and cement. The briquettes are allowed to remain twenty-four hours in air and are then placed in water; some are mixed with fresh water and then placed in salt water; some are mixed with salt water, and placed in salt water; some with fresh water and placed in fresh water. The ages of the briquettes broken to date vary from one week to over one year. There still remain to be broken about 2,800 briquettes; when this is done a special report upon this will be submitted. * * *

The following brands are being tested: Saylor's Portland, Akron's Obelisk, Waring (Howard), McLean's Portland, Scales Portland, and Alsen's Portland.

RE-SURVEY OF HARBOR ENTRANCE.

The re-survey of the harbor entrance, ordered by your letter of April 1, was commenced on the 21st, and has been continued whenever the condition of weather would permit. Aside from this the beach-line and different curves in the neighborhood of Fort McRee have been located and a map compiled.

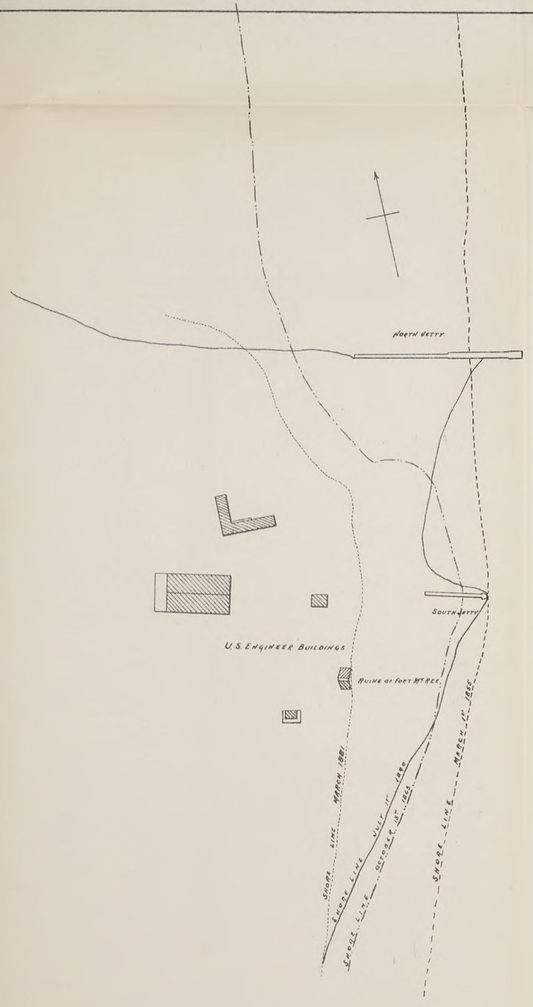
CARE OF PROPERTY.

After the completion of the jetties, the property, consisting of machinery, derricks, tackle, and timber, was properly housed, and machinery thoroughly cleaned and painted.

* * * * * * *

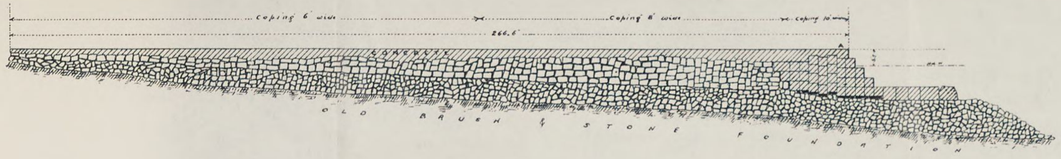
Money statement.

July 1, 1889, amount available		$26,647.21
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$18,492.10	
July 1, 1890, outstanding liabilities	1,147.49	
		19,639.59
July 1, 1890, balance available		7,007.62
Amount appropriated by act of September 19, 1890		25,000.00
Amount available for fiscal year ending June 30, 1891		32,007.62
Amount (estimated) required for completion of existing project		81,446.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		81,446.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

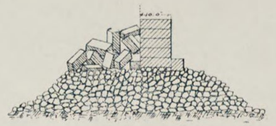


SCALE OF FEET

100 50 0 1 2 3 4 500



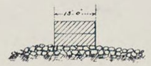
SECTION OF NORTH JETTY



CROSS SECTION AT A



SECTION OF SOUTH JETTY



CROSS SECTION AT B



PLAN

SCALE OF FEET

10 0 50 100

PENSACOLA HARBOR

PLAN SHEWING RELATIVE POSITIONS & SECTIONS OF

JETTIES

BUILT FOR THE PRESERVATION OF THE SHORE LINE NEAR FORT McREE

MADE UNDER THE DIRECTION OF
CAPT PHILIP M PRICE
CORPS OF ENGINEERS U.S.A.

H. Tuttle
Asst Engr.

U.S. Engineer Office
Montgomery, Ala June 30th 1890
To accompany Annual Report for 1890
Philip M Price
Captain of Engineers

PRINT-LITH by E. HOEN & CO. BALTO. MD.

Eng 90

COMMERCIAL STATISTICS.

The collector of the port of Pensacola has kindly furnished the following statistics of the port of Pensacola, Fla., for fiscal year ending June 30, 1889:

Lumber exported.....feet, B. M..	317,428,264
Value of exports to foreign ports	$3,440,835
Value of exports to coastwise ports	138,045
Total	3,578,880
Value of imports from foreign ports	22,605.54
Value of imports from coastwise ports	No record kept.
Total	22,605.54
Duties on imports and miscellaneous collections	32,982.80
Vessels entering and clearing:	
Entering from foreign ports	554
Entering from coastwise ports	60
Total	614
Cleared for foreign ports	579
Cleared for coastwise ports	59
Total	638
Vessels employed in traffic of port:	
Sailing	113
Steam	28
Total	241

Q 5.

IMPROVEMENT OF CHOCTAWHATCHEE RIVER, FLORIDA AND ALABAMA.

PLAN OF IMPROVEMENT.

Under an act of Congress approved March 3, 1871, an examination and partial survey of this river was made from the mouth of the river to Geneva, Ala., an estimated distance of 125 miles, and under an act approved March 3, 1879, a further examination was made from Geneva to Newton, Ala., an estimated distance of 37 miles.

The plan of improvement adopted, pursuant to these examinations, provides for the improvement of the river to obtain a low-water navigable channel from its mouth to Geneva, and a navigable high-water channel from Geneva to Newton, by the removal of snags and logs from the channel and overhanging trees from the banks, and by excavating rock shoals and deepening sand-bars and by works of contraction. This improvement must be maintained by the removal of fresh obstructions each year. The banks of the river are heavily timbered and the annual accumulation is large. The annual cost of this work is estimated at $5,000.

The original estimate of the cost of this improvement, as amended in 1880, was $122,832. This estimate was based upon the supposition that the work would be pushed through in two or three years, whereas the appropriations, as made, have already extended the work through

sixteen years, requiring the expenditure of the greater part of each appropriation, since the first, to clear the portion of the river, previously worked, of snags, etc., which annually formed in the river. Several bars between Geneva and Caryville are now very troublesome at low water, and require works of contraction and shore protection for their improvement. The lack of funds has prevented the making of the surveys necessary for preparing accurate estimates of the cost of improving these points, and it is therefore impracticable to submit an estimate of the amount required for the completion of the existing project.

APPROPRIATIONS.

June 23, 1874	$5,000
March 3, 1875	5,000
August 4, 1876	5,000
March 3, 1879	5,000
June 14, 1880	7,000
March 3, 1881	10,000
August 2, 1882	18,000
July 5, 1884	15,000
August 5, 1886	15,000
August 11, 1888	10,000
Total	95,000

The average annual appropriation has thus been $5,937.50. With this amount it has not been practicable to maintain a suitable plant for expeditious and economical work. The old snag-boat has become useless and has been condemned. A new boat was built under contract by Messrs. M. A. Sweeney & Bro., of Jeffersonville, Ind., at a cost of $4,800, but was not delivered until September, 1889, when the available appropriation was so nearly exhausted that no work could be done with it. The commerce is mainly carried on on that part of the river between Geneva and Caryville, at which point the Pensacola and Atlantic Railroad crosses the river. Geneva is the center and shipping point of a rich and rapidly developing agricultural and timber country, whose only outlet is by means of the Choctawhatchee River to Caryville, Fla., and thence by railroad to points east and west.

The imperfect improvement already accomplished on this portion of the river has resulted in great benefit to navigation, the effects of which are shown by the large increase in the trade of Geneva, and by the rapid settlement of the surrounding country. Four steam-boats now run between Geneva and Caryville; but at low water full loads can not be carried, and they are much delayed by several sand-bars, which could be readily deepened if the appropriations were sufficiently large.

But little work has been done on the river above Geneva. During the summer of 1889, the snag-boat worked its way from Geneva to a point about 2½ miles above Pate's Landing, a distance of 27½ miles in all, and removed the worst obstructions.

In 1889 the legislature of Alabama passed a law prohibiting the driving of loose logs on the Choctawhatchee River in the State of Alabama. This law, however, has not been enforced, and the river between Geneva and Newton is frequently obstructed by log jams.

Since the building of the Pensacola and Atlantic Railroad, there has been but little steam-boat navigation below Caryville, but this portion of the river is much used for the movement of logs and sawn-timber rafts to the market at Pensacola. It is obstructed at low water by logs and snags, but the available funds have not permitted any work to be done on it.

WORK DONE DURING PAST FISCAL YEAR.

Assistant Engineer W. A. Gould, who was in local charge of this improvement until November, 1889, reports as follows:

In June, 1889, the snag-boat had been towed by the steamer *Lena C.* 25 miles up river to Geneva, Ala.; the boat was there provisioned and a crew shipped, and the boat started up river with poles and warp lines.

Not much time was spent in removing obstructions en route, although this portion of the river had not been worked since the season of 1887, and numerous obstructions had accumulated. Only the most troublesome obstructions were removed, and every effort was made to reach Pate's Landing with as little delay as possible.

The portion of the river above here to Hollis' Bridge had never been worked, and the first 3 miles, being through a sandy region, was very much obstructed by changes in the course of the river and by fallen trees, logs, and stumps.

Part of the month of June and the whole of July was spent in this locality in opening a channel-way for high-water navigation.

* * * * * * *

The river was quite low, and to manipulate the snag-boat in a narrow channel at low water required great care, and the progress was necessarily slow.

After advancing about 2½ miles above Pate's Landing further progress was arrested by a "jam" of about 4,000 logs, which by "driving" contrary to the laws of Alabama, had been allowed to accumulate in the river; it being inexpedient as well as dangerous to break this jam the boat was turned about, and as the river had fallen 2 feet, the retreat was nearly as slow as the advance. After reaching Pate's Landing the boat drifted down the river and reached Geneva August 1, thus completing the operations in the upper river for the season of 1889.

The river below Geneva for 25 miles to the crossing of the Pensacola and Atlantic Railroad is of great importance as a route of supplies for the town of Geneva and 30 miles square of adjacent country, it being their only means of communication, and the maintaining of good navigation is of vital importance.

* * * * * * *

During the low-water period, say four months in the year, the channel is obstructed in places by logs, snags, and fallen trees, also by permanent and temporary sand-bars, requiring works of contraction to conserve the water and scour out a temporary low-water channel. The most prominent of these bars are located at "Buzzard's" Bar, "Pitman's" Ferry, Trammel's Woodyard, Harveston's Whirl, and "Little Buzzard's" Bar. The passage through the rocks at the Cerro Gordo Shoals could be improved by the blasting of certain ledges.

All these being extreme low-water impediments have never been operated upon for the reason that the annual appropriation has always been exhausted in the more important work of removal of logs and snags, leaving nothing available for these deeper investigations.

* * * * * * *

The work between Geneva and Caryville was continued until September 30, when the whole plant, for the lack of funds and total suspension of the work, was tied up at Caryville, Fla., together with the new snag-boat, which was received from the builders so late as to be unable to participate in the operations of this season.

* * * * * * *

It is proposed to apply the appropriation asked for to the maintenance of the existing improvement; to the removal of snags and logs from the channel, and overhanging trees from the banks, and to the improvement of such shoals as obstruct navigation.

Money statement.

July 1, 1889, amount available		$8,513.81
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$7,640.04	
July 1, 1890, outstanding liabilities	40.00	
		7,680.04
July 1, 1890, balance available		833.77
Amount appropriated by act of September 19, 1890		12,500.00
Amount available for fiscal year ending June 30, 1891		13,333.77
Amount that can be profitably expended in fiscal year ending June 30, 1892 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		25,000.00

COMMERCIAL STATISTICS.

It is reported that four steamboats have been employed in the carrying trade, mainly between Geneva, Ala., and Caryville, Fla., during the past year as follows:

Vessel.	Length.	Draught.	Net tons.
	Feet.	*Inches.*	
Dexter (new)	100 by 23	20	122½
Dove	116 22	16	98
Falcon	85 20	16	55
Lena C	80 20	18	34

The reported tonnage of the river is as follows:

	Tons.
Timber	96,682
Shingles	290
General merchandise	8,088
Baled cotton	7,800
Guano	3,099
Total	115,959

Q 6.

IMPROVEMENT OF ESCAMBIA AND CONECUH RIVERS, FLORIDA AND ALABAMA.

PLAN OF IMPROVEMENT.

The Escambia and Conecuh rivers are really one river; that portion of theriver from its headwaters in southeastern Alabama to the Florida and Alabama state line being called the Conecuh River, and the portion in Florida being called the Escambia River.

Under an act of Congress approved June 18, 1878, an examination and partial survey was made in 1878 and 1879, from the mouth of the river, at the head of Pensacola Bay, to Indian Creek in Alabama, an estimated distance of 293 miles.

The plan of improvement adopted pursuant to this examination provides for the improvement of the river by the removal of logs and snags from the channel, and overhanging trees from the banks; by excavating rock shoals, deepening sand-bars by works of contraction and shore protection, and by dredging through a bar at the mouth of the river.

The object of the improvement is to facilitate the movement of saw-logs and timber-rafts down the river, and to afford at the same time a suitable channel for steam-boat navigation. The improvement must be maintained by the removal of fresh obstructions each year. The banks are heavily timbered, and the accumulation will be large. It is estimated that an annual appropriation of about $5,000 will be required for the maintenance of the improvement.

The original estimate of the cost of the improvement was $87,430. The limited appropriations have compelled slow progress with the work, and a large percentage of these appropriations has been expended in the removal of the annual accumulation of obstructions due to freshets in the river, and this amount must be added to the original estimate.

The subjoined estimate of the cost of completion of the existing project is the balance of the original estimate, but for the reason just stated it will not be sufficient to complete the project.

APPROPRIATIONS.

June 14, 1880	$8,000
March 3, 1881	5,000
August 2, 1882	12,000
July 5, 1884	15,000
August 5, 1886	12,000
August 11, 1888	10,000
Total	62,000

SUMMARY OF OPERATIONS TO DATE.

The average annual appropriation has thus been $6,200. With this amount it has not been practicable to maintain a suitable plant for expeditious work. One snag-boat has been worn out in service upon this improvement, and another transferred to it from the Cahaba River, which is moderately efficient. Slow but steady progress has been made in the removal of obstructions, and navigation has been greatly benefited.

From its mouth to Thompson's Cut-off, a distance of 133 miles, the river is now in a fairly navigable condition for all stages higher than 2½ feet above low water, and the bar at the mouth of the river has been dredged, and boats have now a free passage over this bar at all stages of water.

WORK DONE DURING PAST FISCAL YEAR.

Assistant Engineer J. E. Turtle, in local charge of this improvement, reports as follows:

At the beginning of the fiscal year the snag-boat, with a crew of 11 men, was employed in removing snags and other obstructions from the river. During the month of July the party reached Thompson's Cut-off. The obstructions at this cut-off consisted of a divided channel, the straighter one being entirely closed with rafts, timber, snags, and logs. This straighter chute was cleared of these obstructions, and the bed of the stream lowered by the excavation of marl and gravel. This work was completed on August 9, when, in accordance with instructions, work of dropping the snag-boat to the mouth of the river was commenced. She reached Skinner and McDavid's Mill, at the mouth of the river, on August 26, when preparations for dredging were commenced. The machinery was taken from the hold, cleaned and placed on deck. The centrifugal pump ordered from Joseph Edwards, New York, not having arrived at this date, the force was suspended.

The pump did not arrive until October 24, and was immediately put in place. The boiler belonging to the snag-boat was found to be insufficient for steaming purposes, and one rented from Mr. Skinner was used in connection with it.

The plan adopted for this dredging was the suspension of the suction-shoe from the forward end of the snag-boat by means of a derrick. The snag-boat, carrying the pump, was towed by the steamer *Celestine*, in and out over the bar, and the discharge pipe was directed into a box, built upon a barge hired for the purpose. The dredged material was removed from this barge by removing the sides of the box or vat, which was nearly as large as the barge, hoisting the suction-shoe from the bottom to insure a discharge of pure water, and then by means of the discharge pipe flooding the dredged material.

* * * * * *

The only tow-boat suitable for the purpose that could be hired, carried too much draught for this work, and at the beginning, the work was greatly delayed by the tug getting aground. The services of the tug could not be had continuously, and many interruptions and much delay were caused by the owners of the tug taking it away at times when its services were indispensable to the dredging. These facts made the work very unsatisfactory and expensive.

Dredging at the mouth of this river was commenced on November 6 and suspended on December 19, when a channel 60 feet in width and 6 feet deep at low water was secured. This channel would have been made deeper, but the constant delays, caused

principally by the tug being called off by the owners, made it advisable to suspend operations. In all, 2,353 cubic yards were removed and dumped in McAvoy's Chute.

On December 20 the snag-boat was tied up for the winter in Governor's Bayou, about 3½ miles from the mouth. The property was properly cleaned and housed.

* * * * * * *

At the close of the fiscal year ending June 30, 1890, the river from Thompson's Cut-off to the mouth, a distance of 133 miles, is in a fair navigable condition for all stages higher than 2½ feet above low water.

The expenditure for fiscal year has improved 28 miles of channel, and secured a free passage to boats entering this river over the bar at the mouth during all stages of water.

Raftsmen, and the captain of the steamer *Mary Alice* (the only freight steamer plying this river), report the river greatly improved, and that the most obstructed portion now lies between Parker's Ferry and Molino. The captains of tugs, entering the river after timber, report that since the dredging no difficulty is experienced in entering the river at all stages of the tide. * * *

The removal of obstructions will begin immediately above Molino.

Work performed during the fiscal year ending June 30, 1890:

Snags removed	530
Trees cut and removed	18
Cubic yards of rock removed	111
Cubic yards of gravel removed	42
Cubic yards of sand dredged from bar at mouth	2,353

It is proposed to apply the amount on hand and the appropriation asked for to the maintenance of the existing improvement, and to prosecuting the work under the approved project to as great an extent as may be practicable.

Money statement.

July 1, 1889, amount available		$7,922.67
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$6,008.29	
July 1, 1890, outstanding liabilities	932.70	
		6,940.99
July 1, 1890, balance available		981.68
Amount appropriated by act of September 19, 1890		7,500.00
Amount available for fiscal year ending June 30, 1891		8,481.68
Amount (estimated) required for completion of existing project		17,930.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		17,930.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

The census for 1880 gives for the counties bordering upon this river a total assessed valuation of real and personal property amounting to $5,649,647, and a total taxation of $118,767.

The river flows through a very extensive district of long-leaf yellow pine, contributing largely to the export trade of Pensacola, Fla., it being claimed by the timber merchants of that port that about 33⅓ per cent. of the entire lumber export comes down the Escambia and Conecuh rivers. This would amount to about $1,000,000.

During the greater part of the past winter the stage of the water has been too low for a convenient navigation of the river, either by the steamer *Mary Alice* or rafts, and the tonnage is thereby reduced, particularly that of general merchandise.

Total tonnage of commerce for the last twelve months:

	Tons.
Timber	345,488
General merchandise	91
Total	345,579

Q 7.

IMPROVEMENT OF FLINT RIVER, GEORGIA.

PLAN OF IMPROVEMENT.

Under an act of Congress approved June 10, 1872, an examination and partial survey of this river was made in 1872 and 1873; and under an act approved June 18, 1878, a further examination was made in 1879.

The plan of improvement adopted pursuant to these examinations, provides for a low-water navigable channel 3 feet deep and 100 feet wide from the mouth of the river to Albany, Ga., an estimated distance of 105 miles; and a navigable channel for light-draught steamers, at moderate stages of water, from Albany to Montezuma, Ga., an estimated distance of 77 miles, to be secured by the removal of snags and overhanging trees, scouring bars by works of contraction, and cutting through the rock-reefs.

For the lower river the work is principally upon the rock bottom of the river, and is of a permanent character. In the upper river, between Albany and Montezuma, there will be a considerable accumulation of snags to be removed.

The original estimate of the cost of this improvement was $184,862 for the lower river, and $15,100 for the upper river, or $199,962 for the entire river.

This contemplated that the improvement should be carried on continuously with sufficient appropriations to provide adequate working plant. Annual appropriations have not been such as to permit the work to be carried on in this way. It has been necessary to spend a large part of the amount available for each year's work in removing the annual accumulation of logs and snags due to freshets. For this reason, the original estimate must be increased for the completion of the original project, but to what extent can not be determined without accurate surveys of the localities needing improvement.

The subjoined estimate of cost of completion of the existing project is the balance of the original estimate.

APPROPRIATIONS.

June 18, 1878	$10,000
March 3, 1879	7,000
June 14, 1880	20,000
March 3, 1881	15,000
August 2, 1882	25,000
July 5, 1884	20,000
August 5, 1886	20,000
August 11, 1888	20,000
Total	137,000

SUMMARY OF OPERATIONS TO DATE.

The average annual appropriation has thus been $11,466.66. With this amount a moderately efficient working plant has been maintained upon the river for rock excavation below Albany, Ga., and for snagging operations between Albany and Montezuma, Ga. A navigable channel, having the proposed depth at low water, and a width varying from 50 to 100 feet has been excavated from the mouth of the river nearly to Albany.

The contemplated width of 100 feet can not be given at all points without risk of lowering too greatly the low-water surface of the river. Above Albany the river has been partially cleared of logs and snags, and to a limited extent of loose rock in the channel between Albany and Montezuma.

The work of rock excavation on the shoals of this river, progressing upwards from the mouth, must be expected to lower to some extent the plane of low water and to develop rock obstructions not included in the original estimate. This cumulative effect appears in the short section of the river between Blue Springs and Albany, where a much larger amount of work is required than was contemplated in the original estimate.

WORK DONE DURING THE PAST FISCAL YEAR.

Assistant Engineer Thomas Robinson, in local charge of this improvement, reports as follows:

A.—Between Albany and Montezuma, Ga., the new snag-boat *Flint* was completed August 17, 1889, and received from the contractors at Coney, Ga. The boat was immediately fitted out and started to work, up-stream, towards Montezuma, On reaching this point, early in October, it was drifted back to its starting place and work begun in the direction of Albany. The available balance of the appropriation allowed but little work on this portion of the river, and on October 30 the boat was laid up at Albany in charge of a watchman.

WORK DONE.

With an average of thirteen men, working sixty-five days, 901 snags, logs, and overhanging trees, an old ferry-boat, and the boiler of a sunken steamer were removed from the channel. These obstructions constituted only the more formidable ones at a moderate stage of water, and were scattered along an estimated distance of 56 miles.

NOTE ON DEPTH OF CHANNEL.

Between Albany and Montezuma the project of improvement calls for a "channel at moderate stages of water." No definite definition of moderate stage has hitherto been given, and a depth of 1 foot below low water has been assumed as the limit. Between Albany and Warwick, an estimated distance of 38 miles, rock shoals abound, and the depth at moderate stage can not be taken beyond the 1-foot limit until measures are adopted for the removal of the rock ledges.

Between Warwick and Montezuma, an approximate distance of 40 miles, few rock shoals occur. The banks are wooded, and in some cases caving, and the obstructions consist of logs and snags. A boat is plying this portion of the river, there is an abundant depth of water in it, and moderate stage here may be considered the same as low water, and the channel cleared to a depth of 3 feet and a width of 100 feet.

JETTIES, ETC.

Nothing in the line of jetties or shore protection has been suggested for this river, but, in spots, something of the kind is needed, and as snags and logs are removed from the channel they will be systematically disposed of as breakwaters until more definite plans are determined.

PROPOSED WORK.

It is proposed to resume operations with the snag-boat as soon as a new appropriation is available. The boat will begin at Albany and work up to the head of navigation at Montezuma.

COST AND TIME.

To complete the improvement as outlined in the present approved project, it is estimated that two full working seasons of eight months each will, at a total cost of $12,000, be required. To maintain the channel, it is estimated that an annual outlay of $3,000 will be needed.

B.—BELOW ALBANY, GEORGIA.

Early in June, 1889, work was resumed with the crew of one drilling barge on the shoals near Albany, and continued until September 30, when, on account of the lack of funds, the work was stopped, and the plant laid up in care of a watchman.

MATERIAL.

The material of these shoals is solid ledge and loose bowlders.

WORK DONE.

During the working period of ninety-six days, with an average force of nineteen men, 77 snags and 1,412 cubic yards of rock were removed from the channel.

ESTIMATE WORK.

It is estimated that 2,160 cubic yards remain to be removed from these shoals at Albany, and that one full season of eight months with one drilling barge will be required for the work.

NOTE ON CHANNEL.

When these shoals at Albany are opened there will be a clear channel, with a least width of 50 feet (and that only at one place), and a depth of 3 feet, extending from Albany to the mouth of the river, a distance of 105 miles, approximately.

Portions of this channel need straightening and widening to render them safe for navigation. Other portions must be left purposely narrow, to maintain the proper depth in pools above the shoals.

WORKING PLANT.

The plant below Albany consists of one new drilling-barge, one dumping-flat, and their complement of sundry hand tools, in good working order. A successful and economic prosecution of the work requires at least two drilling-barges, dumping-flat, etc., and it is respectfully urged that a new barge and flat be built to replace the old ones, which sunk from old age and rot during the past winter.

ESTIMATED TIME TO COMPLETE.

It is estimated that three full seasons of eight months each, with a working plant of two drilling-barges in good equipment, will be required to complete the improvement below Albany.

* * * * * * *

PROPOSED WORK.

It is proposed to resume work on the shoals near Albany with the crew of one drilling-barge as soon as the new appropriation is available.

A tabular showing of the condition of the Flint River below Albany, Ga., would be the same as that of the report of 1889, and it is, therefore, not herein copied.

* * * * * * *

It is proposed to apply the small balance available and the appropriation asked for to the maintenance of the existing improvement and to continuing the improvement in accordance with the approved project.

Money statement.

July 1, 1889, amount available		$14,666.25
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$13,840.01	
July 1, 1890, outstanding liabilities	85.80	
		13,925.81
July 1, 1890, balance available		740.44
Amount appropriated by act of September 19, 1890		20,000.00
Amount available for fiscal year ending June 30, 1891		20,740.44

Amount (estimated) required for completion of existing project.....	$42,962.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	42,962.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

COMMERCIAL STATISTICS.

Above Albany, Ga.—The *Montezuma*, a small steamer of about 90 tons, and having a load draught of 30 inches, has been rebuilt and resumed her regular trips between Montezuma and Warwick in January of the present year. Between the time of its launching and the 1st of May this steamer carried freight as follows:

	Tons.	Value.
Commercial fertilizers	800	$20,000
Lumber, 100,000 feet B. M	208	1,000
Cotton, 2,000 bales	500	100,000
General merchandise	300	50,000
Value of steamer *Montezuma*	.....	4,500
Total	1,808	175,500

Below Albany, Ga.—Between Bainbridge, Ga., and the mouth of the river, with an occasional trip as far as Albany, the steam-boats for the Flint River are the same as those for the Chattahoochee River, and are reported under that improvement.

It has been impossible to secure exact figures for the traffic of this lower river; but the following is the estimated tonnage:

	Tons.
Iron	450
Cotton (6,000 bales)	1,500
Cotton-seed	200
Lumber rafted	1,550
Merchandise (700 bales)	70
Merchandise (171,100 barrels)	17,100
Total tonnage	20,870
Total valuation for lower river	$1,500,610
Total valuation for upper river	175,500
Total valuation of river traffic	1,676,110

The census for 1880 gives for the counties bordering upon this river within the limits of the proposed improvement a total assessed valuation of real and personal property amounting to $13,451,611, and a total taxation of $156,916.

Q 8.

IMPROVEMENT OF COOSA RIVER, GEORGIA AND ALABAMA.

PLAN OF IMPROVEMENT.

In 1870 an instrumental survey of this river was made from Wetumpka, Ala., to the East Tennessee, Virginia and Georgia Railroad Bridge, a distance of 68 miles, and an examination from this point to Greensport, Ala., a distance of 74 miles. In 1872 an instrumental survey was made from the bridge to Greenport. In 1874 an examination was made between Rome, Ga., and Gadsden, Ala., an estimated distance of 133 miles. In 1878 a detailed resurvey was made of Whistenant's and Ten Island Shoals, below Greensport.

Pursuant to these examinations and surveys a plan of improvement was adopted which provided for the removal of the lesser rock shoals and sand and gravel bars, by excavation and by works of contraction, so as to give a minimum depth of 3 feet at low water in the channel, and the construction of locks and dams to overcome the more serious obstructions. The approved project was limited to the section of river between Rome, Ga., and the East Tennessee, Virginia and Georgia Railroad Bridge, an estimated distance of 236 miles.

From Rome to Greensport, an estimated distance of 162 miles, the river has generally a moderate slope which is fixed by railroad surveys at an average of about 6 inches per mile, or deducting the fall at shoals an average slope of about 5 inches per mile in those portions of the river requiring improvements. The banks are generally firm and not easily eroded. In places a movable bottom requires works of contraction for obtaining the required depth in the channel. These constitute but a small portion of the river. Below Greensport the work is mainly upon locks and dams.

The original project provided for locks 40 feet wide and 210 feet between miter-sills, and Locks 1, 2, and 3 have been built with these dimensions. The construction of Lock No. 4 has not yet been begun. The most important coal-fields along the Coosa River are at Broken Arrow between Locks Nos. 3 and 4. The main coal traffic will therefore be up-stream through Locks Nos. 1, 2, and 3 and down-stream through Lock No. 4 and those below it. At Locks Nos. 1, 2, and 3 all tows will have to be broken up, and each tow-boat and barge locked through separately. Between the Broken Arrow coal-fields and Wetumpka it is estimated that twenty-eight locks will be required. Should these locks be made of the same size as those above the additional cost and loss of time occasioned by the necessity of breaking up the tows and passing each boat through the locks separately would be so great that it is doubtful if the traffic could be carried on profitably.

In a report of February 11, 1888, on the improvement as made up to that date, Lieut. Col. William E. Merrill, Corps of Engineers, recommended that the dimensions of Lock No. 4, and those below it, be increased to a width of 52 feet, by a length of 322 feet between the miter sills, which would give an available length of 280 feet, and permit the passage of one tow-boat (25 by 150 feet) and three coal barges (25 by 130 feet) at one lockage. This is the size adopted for the locks now being built on the Black Warrior and Cumberland rivers.

In accordance with these recommendations, by letter of March 20, 1888, the Chief of Engineers directed my predecessor to prepare plans for Lock No. 4, making it 52 feet wide and 322 feet long.

For the above reasons, and in view of the further fact that under the act of August 11, 1888, a survey of the river, from Lock No. 4 to Wetumpka, was then being made for the purpose of preparing revised estimates for its improvement, the estimate submitted for the completion of the existing project in my annual report for the fiscal year ending June 30, 1889, provided only for the completion of the work from Rome, Ga., to and including Lock No. 4, Alabama (52 by 322 feet) 3 miles above the crossing of the Georgia Pacific Railroad.

The survey mentioned was finished early in November, 1889, and my report of the same, with estimates, was submitted under date of December 30, 1889, and printed as House Ex. Doc. No. 94, Fifty-first Congress, first session.

The estimate herewith submitted, for the completion of the existing project, provides for the completion of the channel work required

between Rome, Ga., and Lock No. 4; for the building of the necessary crib-work guiding piers, for the grading and protection of the approaches and grounds, and for the building of lock-keepers' dwellings at locks Nos. 1, 2, 3, and 4; for the completion of the dam and construction of Lock No. 4; and for the completion of the channel work, and the construction of the four locks and dams between Lock No. 4, and the East Tennessee, Virginia and Georgia Railroad Bridge, as estimated in my report of December 30, 1889.

APPROPRIATIONS.

August 14, 1876	$30,000
June 18, 1878	75,000
March 3, 1879	45,000
June 14, 1880	75,000
March 3, 1881	60,000
August 2, 1882	83,700
July 5, 1884	50,000
August 5, 1886	45,000
August 11, 1888	60,000
Total	523,700

SUMMARY OF OPERATIONS TO DATE.

The average annual appropriation has thus been $37,407.14. The principal rock obstructions have been removed from the channel between Rome, Ga., and Gadsden, Ala., and a number of shoals have been improved by wing-dams, so that navigation has been greatly benefited, and a line of steam-boats makes regular trips between these points, and extends these trips to Greensport, Ala., when business demands it.

Below Greensport, at distances, respectively, of .68, 3.86, and 5.24 miles, three permanent masonry locks, with their accessory dams, have been completed; and at Lock No. 4, 21 miles below Lock No. 3, a portion of the coffer-dam in front of the lock and of the west abutment and dam have have been built, and considerable stone has been quarried and cut.

Lock No 1 was completed in January, 1890, and on February 8, 1890, a steam-boat, the *Clifford B. Seay*, passed through the lock. All the machinery worked satisfactorily, and the time of lockage was 8 minutes. Locks Nos. 2 and 3 were completed early in March, 1890, but the opening of them to the passage of boats has been delayed by the necessity of excavating a considerable amount of gravel and rock from the bottom of the canal, connecting Locks Nos. 2 and 3, in order to make the low-water depth in this canal the same as that on the miter-sill of Lock No. 2; namely, 5.2 feet. The work has been much interrupted and delayed by freshets in the river, but was finally completed in the latter part of June, 1890.

On the 28th of June, 1890 the steamer *Annie M.*, of Gadsden, Ala., passed through both locks, and went down as far as the East and West Railroad Bridge and returned. All the lock machinery worked satisfactorily.

In order to permit easy and safe ingress and egress, crib-work guiding-piers are required, and will have to be built at the head and foot of each of these locks. Lock-keeper's dwellings are also required at each lock. The grading and paving, to prevent the washing away during freshets of the Government land and of the banks adjoining the locks, are not yet completed.

Five tracings are forwarded herewith, showing, respectively, a map of the river from Greensport to Lock No. 4, a profile of the river between the same points, and the construction of Locks Nos. 1, 2, and 3.

WORK DONE DURING PAST FISCAL YEAR.

The following extracts from the report of the resident engineer, Mr. D. M. Andrews, will show the work done during past fiscal year:

* * * * * * *

LOCK NO. 1.

The Caméré valves, the type first adopted, were placed in the filling culverts at this lock, but not proving satisfactory were replaced by balanced valves, which have worked admirably up to the present time. The yard, which was badly scoured by the freshet of 1886, has been filled in with earth, and sloped upward from the lock wall with a 1 per cent. grade. The construction of the lower levee has been commenced. The right of way has been graded, and a gate erected at the entrance to the Government property. Gauges have been cut in the walls at the upper and lower ends of the lock, with their respective zeros at the level of the upper and lower miter-sills. The gates and machinery have been painted, hand-rails erected on the gates, gratings placed in front of the filling culverts, and 4 snub-posts placed on the wall and bolted to the masonry. The coffer-dam and bulkhead have been removed, and the lock has been opened to navigation.

* * * * * * *

A lock-keeper was appointed March 1, 1890.

LOCK NO. 2.

The arched culvert and 50 feet of open conduit below the culvert have been completed, and the arch filled over with earth. The right of way from the lock to the public road has been graded, and, wherever necessary, has been macadamized. A fence and gate have been erected across the right of way at the boundary of the Government property. The west bank of the canal, immediately below the lock, has been paved. Gauges have been cut in the walls at the upper and lower ends of the lock, with their respective zeroes at the level of the upper and lower miter-sills. The gates and machinery have been painted, valves placed in the filling culverts and protected by gratings. Four cast-iron snub-posts have been placed on the walls and bolted to the masonry, and hand-rails attached to the gates. A lock-keeper was appointed March 15, 1890.

LOCK NO. 3.

To strengthen it the dam has had a facing of clay and gravel, heavily riprapped, added to it, and the 24-inch cast-iron waste pipe, on the upper side of the dam, has had a section added. The bank of the canal immediately above the north abutment of the dam has been riprapped a distance of 50 feet. A masonry retaining-wall has been built at the end of the dam next the lock, to prevent the earth-facing from sliding in front of the lock. The south bank of the canal has been sloped and partly riprapped from the upper end of the lock to the western limit of the Government property. The work of grading the yard has been nearly completed. The coffer-dam immediately in front of the lock has been taken down 2 feet lower, and the material used in leveling up the foundation for a guiding-pier. The culvert valves for both filling and emptying culverts, and the culvert gratings, have been placed in position. Gauges have been cut in the walls at the upper and lower ends of the lock, with their respective zeroes at the level of the upper and lower miter sills. The gates and machinery have been painted, hand-rails attached to the gates, and four cast-iron snub-posts placed on the walls and bolted to the masonry.

LOCK NO. 4.

No work has been done at this lock during the year, and a watchman has had the care of the buildings and property. Measurements of the current velocity for different stages of the river have been continued. The proposed Government property and rights of way have been surveyed and staked out.

CHANNEL WORK.

The river has been cleared of obstructions between Locks Nos. 1 and 2. The canal between Locks Nos. 2 and 3 has been excavated to the level of the lower miter-sill at Lock No. 2 and to a bottom width of 80 feet.

MISCELLANEOUS.

All buildings at Lock No. 3 have been moved onto the Government property and the rental of land at this lock has been discontinued. All necessary repairs of buildings, wagons, carts, and tools have been made as needed.

The attached table gives the location, quantities, and cost (for labor) of work done during the fiscal year ending June 30, 1890, wherever the work was of such a character that quantities could be given:

Location of work.	Masonry.						Excavation exclusive of channel work, earth.	
	Rubble.		Dry rubble.		Paving and riprap.			
	C. yds.	Cost.	C. yds.	Cost.	C. yds.	Cost.	C. yds.	Cost.
Lock No. 1	.....	.....	.....	.....	93	$172.31	6,118	$2,955.41
Lock No. 2	428	$1,788.13	57	$241,02	493	1,161.50	6,779	1,798.50
Lock No. 3	31	42.85	.....	.....	923	520.42	3,346	1,283.25
Totals	459	1,830.98	57	241.02	1,509	1,854.23	16,313	6,037.16

Location of work.	Quarrying.				Channel-work excavation.			
	Stone quarried.		Stripping.		Silt and gravel.		Solid rock.	
	C. yds.	Cost.	C. yds.	Cost.	C. yds.	Cost.	C. yds.	Cost.
Lock No. 1	.....	.....	.....	.....	.....	.....	115	$279.22
Lock No. 2	2,413	$2,254.73	273	$21.37	4,313	$2,007.32	1,489	1,826.57
Lock No. 3	66	53.70	.....	.....	37	13.80	.....	.....
Totals	2,479	2,308.43	273	21.37	4,350	2,021.12	1,604	2,105.79

Money statement.

July 1, 1889, amount available		$35,704.66
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$31,675.97	
July 1, 1890, outstanding liabilities	3,326.05	
		35,002.02
July 1, 1890, balance available		702.64
Amount appropriated by act of September 19, 1890		300,000.00
Amount available for fiscal year ending June 30, 1891		300,702.64
Amount (estimated) required for completion of existing project between Rome, Ga., and East Tennessee, Virginia and Georgia Railroad Bridge.		971,840.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		500,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

Attention was first called to the improvement of this river by the opportunity which it offers, by canal connection with the Tennessee, for an outlet to the Gulf from the Upper Tennessee, as well as from the valley of the Coosa and its tributaries,

PROFILE OF THE COOSA RIVER

FROM LOCK Nº4 ALA. TO GREENSPORT ALA.

From Surveys made by R.C.McCalla in 1878 and M.T.Singleton in 1882

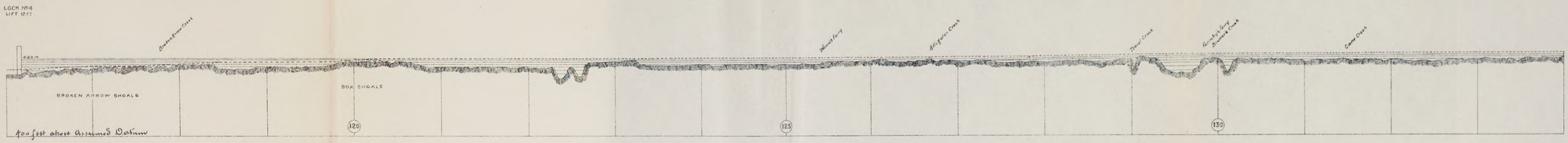
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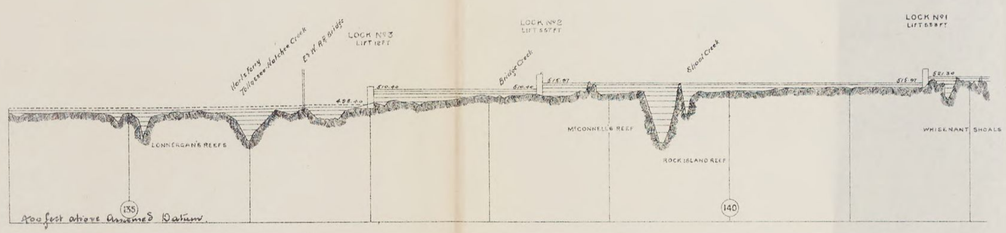
Captain Philip M. Price. Corps of Engineers U.S.A.

DRAWN BY D.M.ANDREWS AND H.ARCHBALD

JUNE. 1890.

Mileage from Wetumpka Bridge shown thus (120)
Line of Mean Low Water . . ----------
Proposed Channel Work . . ~~~~~





HORIZONTAL SCALE
1 0 1 2 MILES

VERTICAL SCALE
100 50 0 100 200 FEET

U.S. Engineer Office
Montgomery Ala. June 30th 1890
To accompany Annual Report for 1890
Philip M. Price.
Captain of Engineers

Photo-Lith. by A. HOEN & CO., Balto., Md.


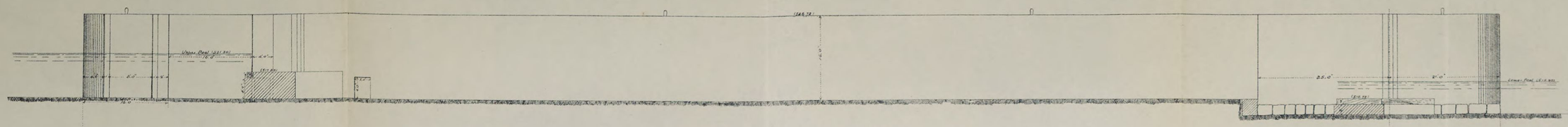


PHOTO LITH. BY A. HOEN & CO. BALTIMORE, MD.

COOSA RIVER, ALA.

LOCK Nº 1

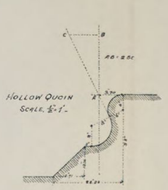
MASONRY PLAN



LONGITUDINAL SECTION

MADE UNDER THE DIRECTION OF
CAPT PHILIP M. PRICE,
CORPS OF ENGINEERS. U.S.A.

MAY 1890.

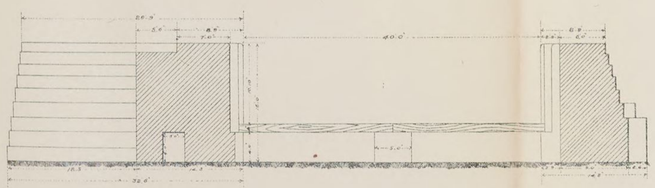


PLAN

SCALE, $\frac{1}{16}$ IN. = 1 FT.

U.S. Engineer Office
Montgomery Ala. June 30th 1890
To accompany Annual Report for 1890
Philip M. Price
Captain of Engineers

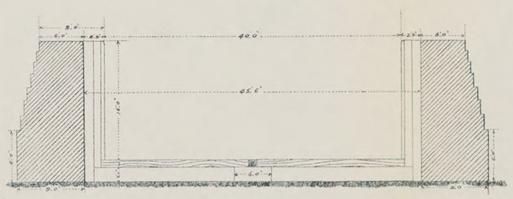
Chas. W. Foster
D. W. Andrews
} Asst. Engineers



SECTION A——B



SECTION C——D



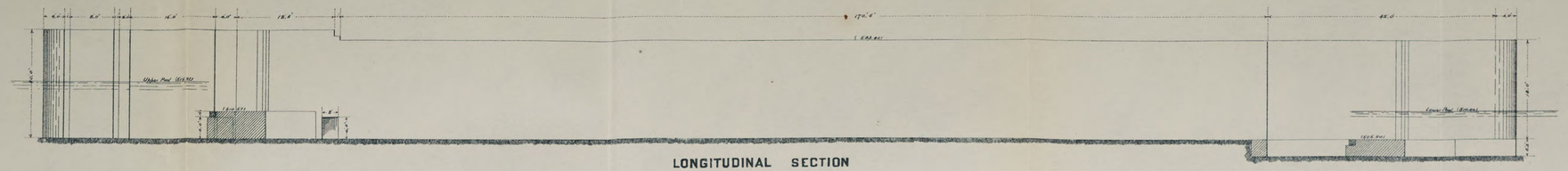
SECTION E——F

U.S. ENGINEER OFFICE
MONTGOMERY, ALA.



SECTIONS

Photo-Lith. by A. HOEN & CO., Balto., Md.



LONGITUDINAL SECTION

COOSA RIVER, ALA.

LOCK Nº2

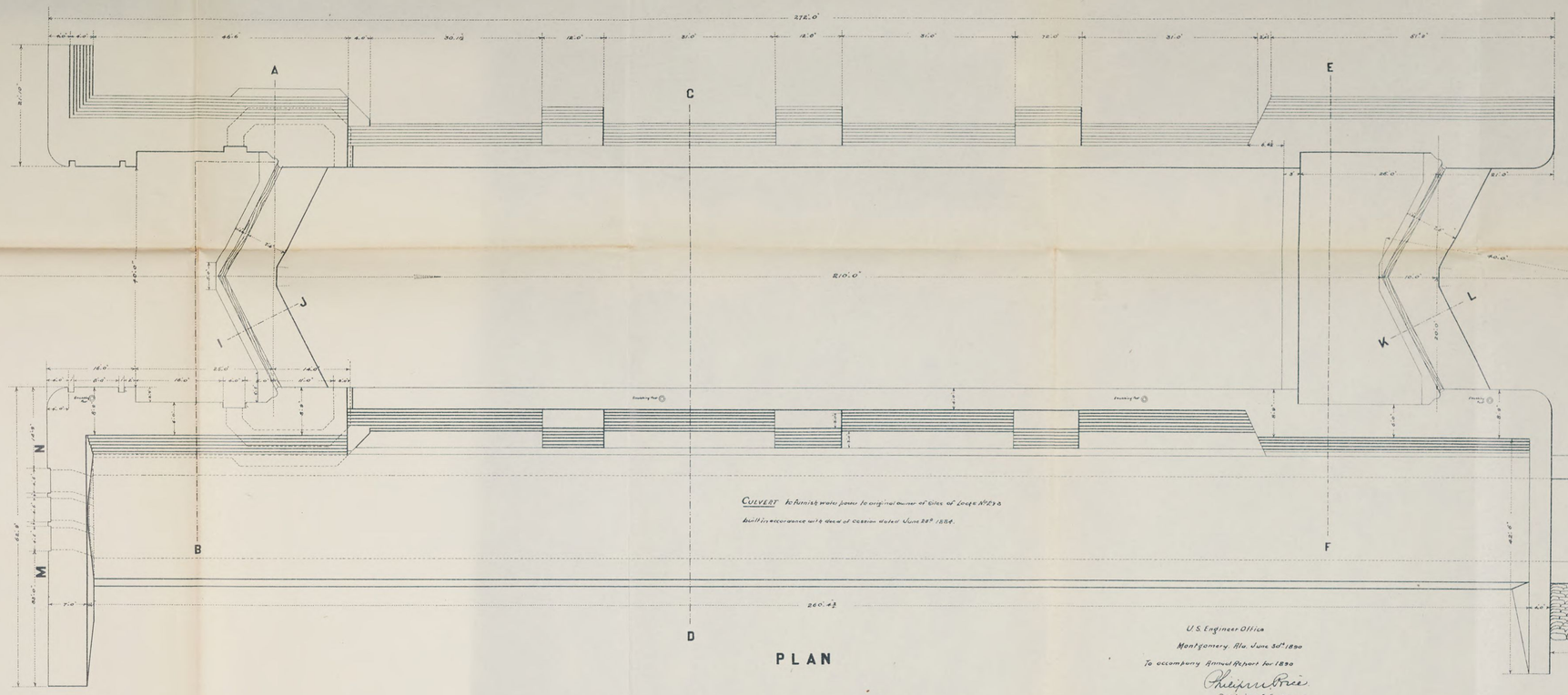
MASONRY PLAN.

SCALE, 1/16 IN. = 1 F'T.

MADE UNDER THE DIRECTION OF
CAPT PHILIP M. PRICE.
CORPS OF ENGINEERS. U. S. A.

MAY. 1890.

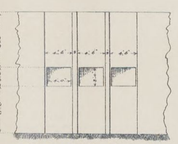
Charles Platt, Asst Engineers
D. M. Crockwell



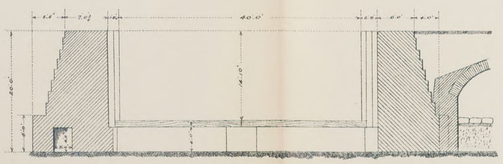
PLAN

U.S. Engineer Office
Montgomery, Ala. June 30th 1890
To accompany Annual Report for 1890
Philip M. Price
Captain of Engineers

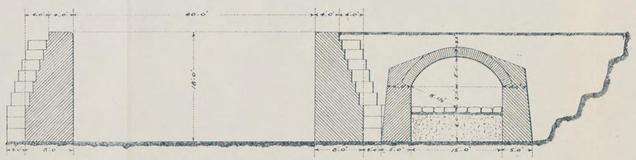
U.S. ENGINEER OFFICE
MONTGOMERY, ALA.



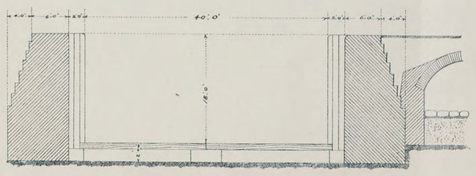
ELEVATION M——N



SECTION A——B



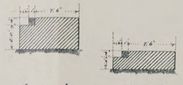
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SECTION E——F



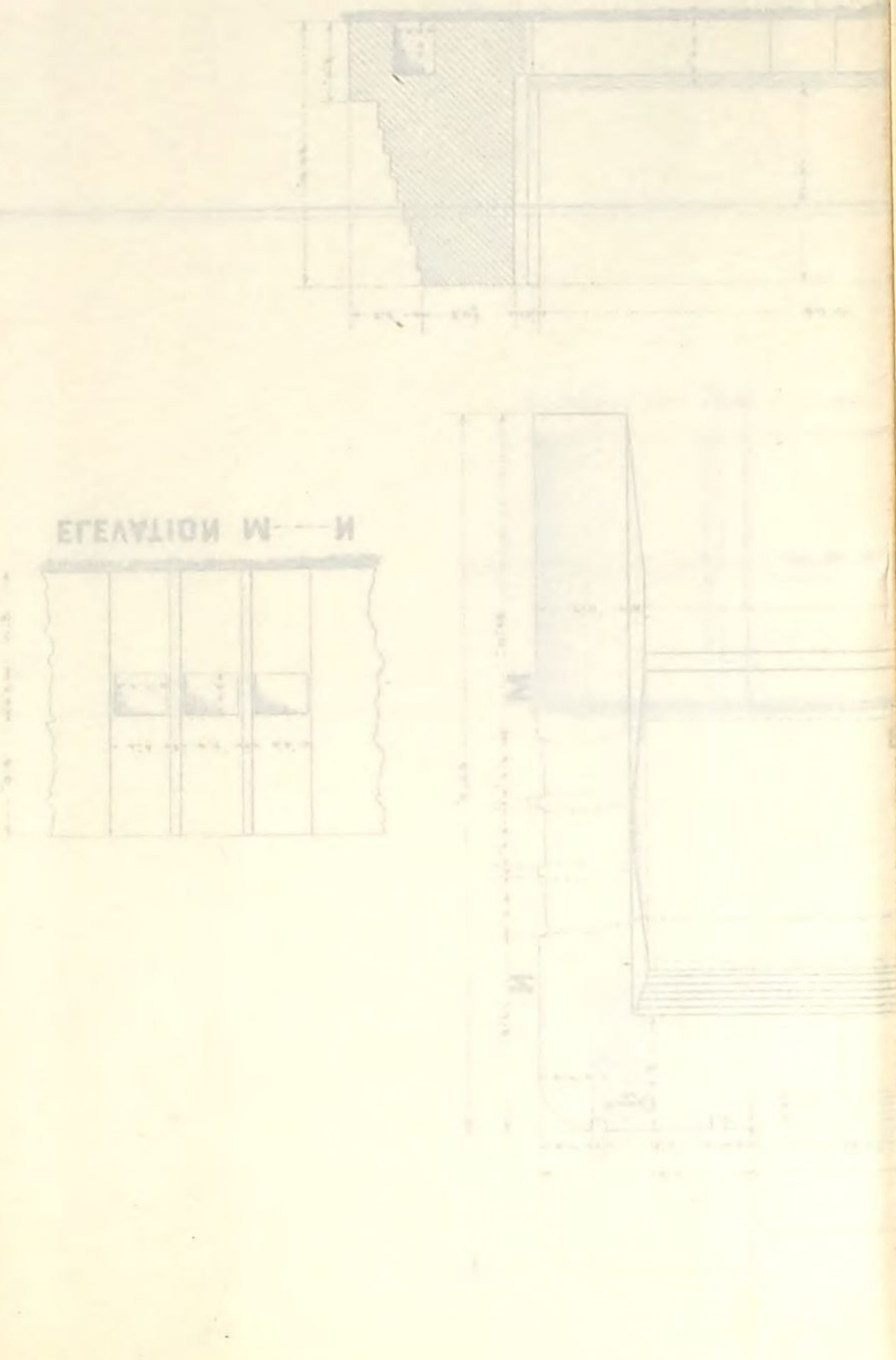
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SECTIONS

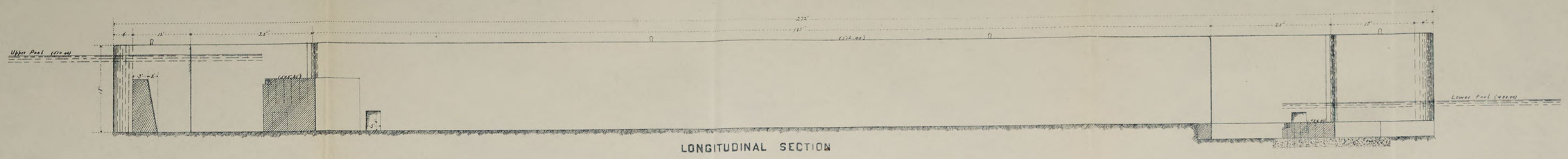
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COOSA RIVER ALA.

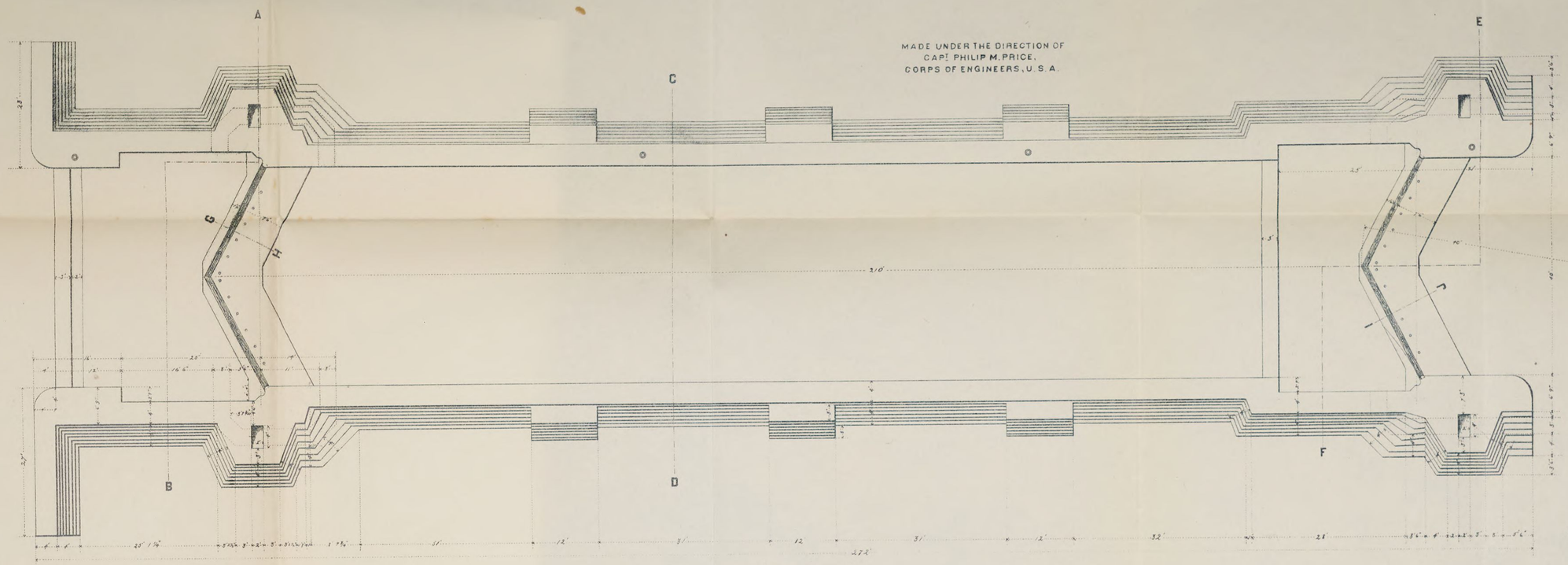
LOCK No 3

MASONRY PLAN



LONGITUDINAL SECTION

MADE UNDER THE DIRECTION OF
CAPT PHILIP M. PRICE,
CORPS OF ENGINEERS, U. S. A.

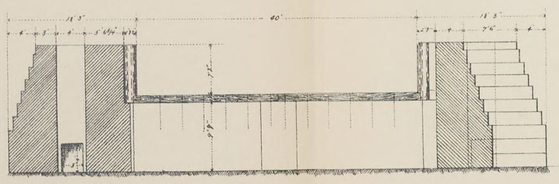


PLAN
SCALE 1 IN = 16 FT

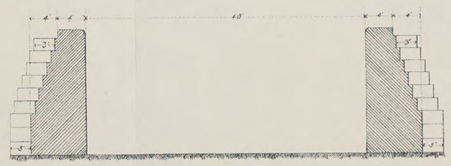
U.S. Engineer Office
Montgomery Ala. June 30th 1890
To accompany Annual Report for 1890
Philip M. Price
Captain of Engineers

U.S. ENGINEER OFFICE
MONTGOMERY, ALA.

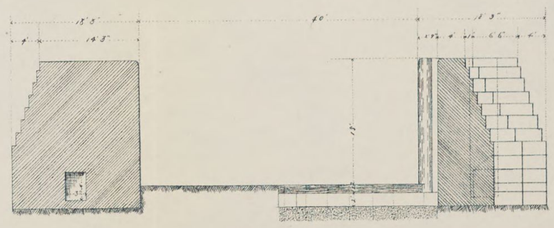
Chas. W. Foster
D. M. Andrews
Asst. Engineers



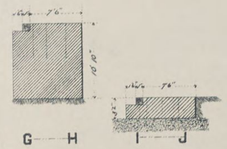
SECTION A — B



SECTION C — D



SECTION E — F



G — H I — J

SECTIONS

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and, later, by the availability of the Coosa River as a link in the proposed line of water transportation from the Northwest by the Mississippi and Tennessee to the Atlantic coast. In 1823 the State of Alabama passed an act in aid of the proposed work of improving the navigation of this river with a view to its connection with the waters of the Tennessee, and in 1824 this act was finally approved by Congress. In 1828 the first appropriation by act of Congress was made for this improvement. A careful survey has demonstrated the practicability of the proposed connection between the Coosa and Tennessee by canal, but the estimated cost, which is nearly $12,000,000, has probably prevented action. It was the prospective navigation to follow the improvement of this river and its connection with the Tennessee which was originally considered in support of the project.

In the meanwhile the coal and iron interests of Alabama have been rapidly developed, and the Coosa River coal and iron fields have become the objective of the more recent plans of improvement. The extension of the improvement to Wetumpka will unquestionably build up a large traffic in coal, iron, and farm products between north Alabama and Mobile and intermediate points, and a large export business in coal from Mobile.

The present local business upon this river should not be taken as a measure of the value of this improvement.

The traffic upon this river during the past fiscal year is reported as follows:

Commodities carried.	Tons.	Value.
Cotton	55,000	$1,100,000
Grain, hay, and flour	97,185	233,028
Fertilizers	6,600	99,000
Miscellaneous merchandise	6,600	102,190
Lumber (B. M.)	1,765	49,500
Total	167,150	1,583,718

This traffic was carried on by steam-boats which were regularly employed between Rome, Ga., and Greensport, Ala.

For detailed statistics relating to this improvement see copy of memorial presented to Congress by the Coosa River improvement convention, assembled at Montgomery, Ala., March 15, 1887, extracts from which are printed in House Ex. Doc. No. 94, Fifty-first Congress, first session.

Q 9.

IMPROVEMENT OF CHATTAHOOCHEE RIVER, GEORGIA AND ALABAMA.

PLAN OF IMPROVEMENT.

Under an act of Congress approved March 3, 1871, an examination and partial survey of this river were made from Columbus, Ga., to Eufaula, Ala. In 1872, and 1873, the examination and partial survey were carried to the mouth of the river, at Chattahoochee, Fla. Pursuant to these examinations a plan of improvement was adopted which provides for a low-water channel 4 feet in depth and 100 feet in width from Columbus, Ga., to Chattahoochee, Fla., a distance of 224 miles, by the removal of snags and other obstructions from the channel and overhanging trees from the banks; by cutting a channel through the rock shoals, and deepening sand-bars by works of contraction. This improvement, at many points, is of a permanent character, the bottom of the river being of rock, and the banks not easily eroded. At other points, the river has a movable bottom and caving banks, and the improvement is attended with the uncertainties, which are characteristic of local works of contraction under such circumstances.

An annual expenditure—estimated at $10,000—will be required for the removal of obstructions constantly accumulating in the channel,

and for the maintenance of the works of contraction and their further extension or modification as required.

The original estimate of the cost of this improvement is stated in the annual report of the officer in charge for 1886, to be $385,247.66. To this must be added the cost of removing the obstructions brought into the river channel by freshets since the date of the original estimate, and the cost of maintaining and modifying the works of contraction.

The subjoined estimate of the cost of completion of the existing project is the balance of the original estimate, but it is apparent that this amount will not suffice for the completion of the original project. That estimate contemplated much larger annual appropriations than have been made, and, in addition, annual appropriations for the maintenance of the improvement. The approved project can not be carried out unless larger annual appropriations are made.

For several years past, on account of the want of funds, no new contraction works have been built, and only slight repairs have been made to those previously constructed. The latter consisted of pile, brush, and stone jetties and training-walls, and are all now much in need of repair, and unless this is done promptly the cost will be greatly increased.

APPROPRIATIONS.

June 18, 1878	$18,000
March 3, 1879	15,000
June 14, 1880	20,000
March 3, 1881	20,000
August 2, 1882	25,000
July 5, 1884	35,000
August 5, 1886	20,000
August 11, 1888	20,000
Total	173,000

Previous to 1878 three appropriations, amounting to $70,000, had been made by the "Chattahoochee and Flint rivers," together.

SUMMARY OF OPERATIONS TO DATE.

The average annual appropriation has thus been $14,416.66. With this amount it has been practicable to maintain a good working plant for snagging operations, to clear the channel of all obstructions of that character, and to remove the annual accumulation, except during limited periods, when funds were not available. It has also sufficed to maintain a moderately efficient working plant for operations upon the rock shoals. Works of contraction have been constructed to a limited extent, but it has not been practicable to keep them in repair, nor to extend or modify them as required. Navigation has been greatly benefited by the improvements, so that steam-boats now make regular trips between Columbus, Ga., and Apalachicola, Fla., running by night as well as by day, and with but few accidents or detentions, except at extreme low water. Formerly they could only run by day, and were frequently detained several days at an obstruction, and many boats were sunk by striking logs or snags.

WORK DONE DURING PAST FISCAL YEAR.

Assistant Engineer Thomas Robinson, in local charge of the improvement, reports as follows:

Early in June, 1889, the snag-boat *Chattahoochee* began work at Burdock's Landing and cleared the river 17 miles, up to Columbus, Ga. The boat was then run down to

Chattahoochee, Fla., and worked back, 206 miles, to the starting point. At the close of August, the prominent drift obstructions having been removed from the channel, the snag boat was laid up, and its crew transferred to the new drilling barge to begin the removal of rocks at the "Widow Brown's" shoals, 197 miles below Columbus, Ga. The work on these shoals was brought to a close from exhausted appropriation, on October 31. A fair practical channel of an average width of 50 feet was cleared, and the dump so deposited that the improvement will stand as it is until another appropriation admits of completion.

From the lack of funds and suitable working plant, nothing could be done in the way of repairs, or additions to the jetties, shore protections, and other works of contraction, built of perishable materials.

WORK BY SNAG-BOAT.

With an average force of 16 men, during the three months, the snag-boat removed 604 logs, snags, and overhanging trees.

BY DRILLING-BARGE.

With a force of 24 men, working two months, the drilling-barge removed 576 cubic yards of rock, 10 cubic yards of marl, cut 12 cords of brush, planted 98 willows, made 330 lineal feet of rock-dump jetties, and laid 228 square yards of brush and rock-dump bank protection.

NOTE ON GENERAL IMPROVEMENT.

The improvement of the Chattahoochee River involves three classes of work: (1) The removal of trees, logs and other drift material, (2) the clearance of rock shoals, and (3) the control of sand and gravel-bars, and caving banks. These three processes should be carried on at one and the same time, for, while each kind of work requires a special plant for its successful prosecution, a union of the working plants, at one point, is frequently required.

DRILLING BARGES.

Two drilling-barges are needed for economic service. One new drilling-barge, in good condition, is on hand; also an old one, which can be made to do some further service, but is not reliable for heavy work.

A pile-driving boat is required at once, for service on the jetties, and other works of contraction.

NEEDS OF THE IMPROVEMENT.

The winter rains, between November, 1888, and March, 1890, caused no freshets in the Chattahoochee River, and consequently there has been but little drift brought into the stream, and no caving of banks.

Some of the prominent places needing improvement are at—

Rock and marl obstructions:

Kowikee Shoals, marl obstructions, 75 miles below Columbus.

Francis Bends, marl obstructions, 80 miles below Columbus.

Widow Brown's (incomplete), rock, 197 miles below Columbus.

King's Rock, and near it, rock, 200 miles below Columbus.

(A steamer was sunk on these rocks).

Rock Island, rock obstructions, 214 miles below Columbus.

Sand Bars:

Mound Bar, sand and gravel obstructions, 7 miles below Columbus.

Woolfolk's Bar, sand, and gravel obstructions, 10 miles below Columbus.

(These two sand-bars badly obstruct navigation. Boats are grounding on them at almost every low water, when loaded to the 3-foot line.)

Francis Bends, sand and mud, 80 miles below Columbus; and other points along the river, need repairs to the jetties now in place, and new works added thereto. Delay in repairs to these jetties, etc., is hazardous, and greatly increases the ultimate cost of improvement. Had the two past winters been as prolific as the two previous, of freshets, the river at Woolfolk's and Mound bars would have been impassable to the steamers.

RECOMMENDATION FOR NEW PLANT.

I earnestly recommend the building of a pile-driving boat, at a maximum cost of $4,000; a drilling-barge at a maximum cost of $3,000, and a dumping-flat at a maximum cost of $200.

* * * * * * *

COST FOR ONE YEAR—ESTIMATE.

With a full working plant for all three lines of work, as indicated above, $75,000 can be profitably expended during the fiscal year ending June 30, 1892.

* * * * * * *

TABLE OF IMPROVEMENTS.

The table showing the condition of the improvement remains the same as that in the report for 1889, excepting there should be added thereto the following improvement:

No. 18, Widow Brown's Shoals, 197 miles from Columbus, 26 miles above Chattahoochee, original depth 2 feet, present deph 4 feet, original width of channel 20 feet, present width 70 feet. Remarks, hard rocks blasted and removed, rock jetties and shore protection built, and willows planted.

It is proposed to apply the small balance available, and the appropriation asked for to the maintenance of the existing improvement, and to its extension as called for by the original project.

Money statement.

July 1, 1889, amount available		$12,376.60
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$10,191.30	
July 1, 1890, outstanding liabilities	569.72	
		10,761.02
July 1, 1890, balance available		1,615.58
Amount appropriated by act of September 19, 1890		20,000.00
Amount available for fiscal year ending June 30, 1891		21,615.58
Amount (estimated) required for completion of existing project		192,247.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		75,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

The census of 1880 gives for the counties bordering upon this river, within the limits of the proposed improvement, a total assessed valuation of real and personal property amounting to $20,272,275, and a total taxation of $271,575.

During the fiscal year ending June 30, 1890, eight boats navigated this river. One of these was sunk upon King's Rock, but was raised and repaired. Another struck the same rock, but was kept from sinking, and repaired at a cost of $1,200.

These eight boats have a draught ranging from 18 inches to 42 inches; tonnage, 1,124, and a valuation of $133,400. During the year April 30, 1889, to April 30, 1890, these boats carried freight as follows:

	Tons.
Commercial fertilizers and cotton-seed products	11,030
Iron	573
Cotton seed	845
Cotton (31,500 bales)	7,875
Grain (190,257 bushels)	7,134½
Lumber (225,000 feet, B. M.)	475
Merchandise (2,816 bales)	281½
Merchandise (684,430 barrels)	68,443
Live-stock (550 head)	138
Total tons	96,795

(Weight in tons estimated.)

Total valuation of—	
Freights carried	$8,634,845.00
Boat earnings	132,257.88
The eight steam-boats	133,400.00
Aggregate value of river business	8,900,502,88
Aggregate value in 1886	8,567,948.00

Q 10.

IMPROVEMENT OF TALLAPOOSA RIVER, ALABAMA.

PLAN OF IMPROVEMENT.

Under an act of Congress approved June 14, 1880, an examination and partial survey of this river was made, which resulted in the adoption of a project for improvement designed to obtain a navigable channel from its junction with the Coosa River where the two rivers form the Alabama to the foot of Tallassee Reefs, 2 miles below Tallassee, the head of navigation, a distance of 48 miles, the channel in open river to be 200 feet in width with a least depth of 3 feet at low water, and in rock cuts to be 60 feet wide and 3 feet deep at low water. The project is to be accomplished by the removal of snags, logs, etc., from the channel, the cutting of overhanging timber from the banks, by rock and gravel excavation through reefs, and by deepening sand-bars by works of contraction and shore protection. The river generally presents long reaches of fine open navigable water, with a width of 200 to 300 feet and depth of 6 to 12 feet. When this width is exceeded to any extent sand-bars and gravel or rock reefs are found. The banks generally of the first 30 miles below Tallassee are firm and stable, but those of the lower river are of soft unstable material which yields readily to the eroding action of the river when unprotected by a growth of brush or cane.

The river runs through a continuous succession of rich bottom land, largely cultivated, and adjacent uplands of good arable soil, with the more hilly portions covered with forests of fine pine timber. The falls at Tallassee furnish magnificent water-power, which is now partly utilized by extensive cotton-mills. The river is not susceptible of permanent improvement, and will require an annual appropriation estimated at $5,000 for the removal of obstructions constantly accumulating in the channel and for the maintenace of the works in order to maintain it in the condition contemplated by the plan of improvement.

The original estimate of the cost of the improvement was $40,125. This estmate contemplated the making of sufficient appropriations to complete the improvement in two or three seasons, but work so far has been extended over a period of 8 years with insufficient appropriations, and the greater part of the money available has in consequence been expended in removing the annual accumulation of logs and snags. An estimate of the amount required for the completion of the existing project can not be submitted without further detailed surveys, for which funds have not been available.

APPROPRIATIONS.

August 2, 1882	$15,000
July 5, 1884	10,000
August 5, 1886	7,500
August 11, 1888	7,500
Total	40,000

SUMMARY OF OPERATIONS TO DATE.

The average annual appropriation has thus been $5,000, and with this amount it has been practicable, besides completing and equipping a suitable snag-boat, to keep only one small working party upon the improvement. The operations have been confined to the removal of logs and snags from the channel; cutting down and removing the most dangerous overhanging timber; building 320 feet of temporary jetty; re-working each year the part passed over during the previous season, and extending the improvement as far up-stream as the funds available would permit.

At the close of the season's work, in November, 1889, there was a fairly navigable channel for light-draught steamers from the mouth of the river to Cowle's Ferry, a distance of 43 miles. The shoals, which owed their existence to logs and snags, have disappeared on the removal of the same. Sunken Reef, 35 miles above the mouth; Zimmerman's Reef, 38 miles above the mouth, and Goodwin's Reef, 39 miles above the mouth, are composed of scattered bowlders and ledges of soft rock, on which there is a depth of but 1 to 2 feet of water at extreme low water. A channel 3 feet deep and 60 feet wide can be readily cut through these reefs when the necessary funds are provided.

WORK DONE DURING PAST FISCAL YEAR.

Assistant Engineer C. B. Percy, in local charge of the improvement, reports as follows:

The snag-boat *Tallapoosa* was at Dawson's Ferry, 25 miles above the junction, July 1, 1889. The party continued working up-stream during the remainder of the low-water season, reaching Buzzard Bar No. 2, 43½ miles above the mouth, on October 25. The channel of this portion of the river, a distance of 18½ miles, was thoroughly cleared of all logs and snags, and all overhanging timber on the banks dangerous to navigation, or liable to fall into the river, was removed. The stage of water being such as to prevent further progress up-stream, the working party was ordered to turn back and move as rapidly as possible down the river, removing such logs or snags as may have been brought during the summer freshets into the channel of that portion of the river between Dawson's Ferry and the junction which had been worked over during the spring. The party reached the junction of this river with the Coosa on November 23; and the funds available for this improvement being nearly exhausted, the plant was brought to Montgomery, party discharged, and operations suspended November 24 for the winter.

Total number of—

Logs or snags removed from the channel during the fiscal year ending June 30, 1890	1,184
Stumps on banks cut level	631
Logs or drift on banks cut up	564
Overhanging trees felled and removed	564
Overhanging trees trimmed	137

Swamped and sunken ferry-boat at Hatchet's Ferry raised.

During the months of April, May, and June the plant was thoroughly overhauled and repaired; very considerable and much-needed improvement made both in the machinery and quarters of the boat, and the entire plant is now in excellent condition. * * *

It is proposed to apply the appropriation asked for to maintaining the existing improvement by the removal of any recently deposited obstructions from the channel, and to the further extension of the improvement by excavating a channel through Sunken, Zimmerman's, and Goodwin's reefs.

Money statement.

July 1, 1889, amount available		$4,180.66
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$3,829.24	
July 1, 1890, outstanding liabilities	184.72	
		4,013.96
July 1, 1890, balance available		166.70
Amount appropriated by act of September 19, 1890		4,000.00
Amount available for fiscal year ending June 30, 1891		4,166.70
Amount that can be profitably expended in fiscal year ending June 30, 1892 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		15,000.00

COMMERCIAL STATISTICS.

Assistant Engineer C. B. Percy, in charge of this improvement, reports as follows:

"The census for 1880 gives, for the counties bordering upon this river within the limits of the proposed improvement, a total assessed valuation of real and personal property amounting to $13,528,123, and a total taxation of $258,052.

"The total commercial value of agricultural products, actual and estimated, of the section tributary to the proposed improvement, amounted in 1889 to $2,100,000. The business on the river has been confined, heretofore, mainly to rafting of pine logs and hewn pine and oak timber. Responsible parties of Montgomery propose to put a steamer on this river, to run regular trips between Montgomery and the foot of the Tallassee Falls, as soon as they are sure of 3 feet of water at low stage to the latter point. Large cotton factories are established at Tallassee, the head of the present improvement."

Q 11.

IMPROVEMENT OF CAHABA RIVER, ALABAMA.

PLAN OF IMPROVEMENT.

Under an act of Congress approved June 23, 1874, and an act approved June 14, 1880, an examination and partial survey of this river was made in 1874, and a further examination and partial survey in 1880, pursuant to which the present plan of improvement was adopted. This comtemplates obtaining a channel 60 feet in width and 3 feet in depth, at low water, from its mouth to the town of Centreville, a distance of 88 miles, by the removal of snags, logs, etc., from the channel, cutting overhanging trees from the banks, protecting caving banks from further erosion, removing rock-reefs and gravel-bars by blasting and dredging, and sand-bars by works of contraction, and by widening narrow portions of the river at certain specified points.

This river, within the limits of the proposed improvement, has generally a movable bottom and caving banks, with a mean slope of about 1½ feet to the mile, which increases at certain points to over 9 feet per mile. The improvement will have that degree of permanence which can be given by local works of contraction to rivers having such characteristics. An annual expenditure will be required for the removal of

obstructions constantly accumulating in the channel, and for the maintenance of the works; and a further extension of these works will be required.

The original estimate of the cost of this improvement is $195,000. To this must be added the cost of removing obstructions brought into the river channel by freshets since the dates of the original estimate. The subjoined estimate of cost of completion of existing project is the balance of the original estimate. Owing to the insufficiency of the annual appropriations, these have been largely consumed in the maintenance of work. To what extent the original estimate must now be increased can not be determined without further detailed survey.

APPROPRIATIONS.

August 2, 1882	$20,000
July 5, 1884	10,000
August 5, 1886	7,500
Total	37,500

SUMMARY OF OPERATIONS TO DATE.

The average annual appropriation to August 5, 1886, had thus been $7,500. With this amount it had been practicable to build and equip a moderately effective working plant for snagging operations, to clear the channel of all obstructions of that character, and remove annual accumulations up to the close of the fiscal year ending June 30, 1886. Since that time no work has been done. An appropriation of $7,500 was made for this work by the river and harbor act, approved August 5, 1886, with a proviso "that no part of said sum shall be expended until the officer in charge shall have reported that the railroad and other bridges across said river have been provided with good and sufficient draw openings." The bridges which obstruct the navigation of this river, and under existing law prevent the expenditure of the appropriation, otherwise available, have been heretofore reported and the report printed in Senate Ex. Doc. No. 12, Forty-ninth Congress, first session. One of these is the Selma and New Orleans Railroad Bridge, about 10 miles above the mouth of the river, and the other the Alabama Central Railroad Bridge, about 22 miles above the mouth. These bridges continue to obstruct the navigation of the river, not having been provided with draw openings.

WORK DONE DURING PAST FISCAL YEAR.

For the reasons above stated no work has been done upon this river during the past fiscal year. The working plant was transferred to the improvement of the Escambia and Conecuh rivers, Florida and Alabama, in 1887, when there appeared to be no prospect of its employment on the Cahaba. The plant is perishable, and would be a dead loss if kept idle indefinitely.

By letter from office of the Chief of Engineers, dated March 28, 1890, a complaint of Hon. J. E. Cobb, M. C., against the bridges on the Cahaba River, was transmitted to me for investigation and report in accordance with the instructions of the Secretary of War, published in General Order No. 9, Headquarters Corps of Engineers, U. S. Army, October 22, 1889.

As I was about departing from my station, on leave of absence, authority was subsequently granted to have my assistant, Lieut. C. L.

Potter, Corps of Engineers, take charge of the matter. Under date of April 26, 1890, Lieutenant Potter submitted the following report to the Chief of Engineers:

* * * * * * *

Captain Price also wrote to Mr. Cobb, asking whether he wished to appear as complainant himself, or refer us to some one more directly concerned, but no answer to this letter has been received.

The bridges over the Cahaba River between Centerville, the head of navigation, and its mouth, are two railroad bridges. One, owned by the Birmingham, Selma and New Orleans Railroad, is about 10 miles from the mouth of the river, and the other, owned by the Alabama Central Division of the East Tennessee, Virginia and Georgia Railroad, is about 22 miles above its mouth.

I made a personal inspection of these bridges on April 15, 1890, and have prepared a tracing showing their dimensions, a copy of which is herewith inclosed. This inspection was delayed on account of high water.

The bridges are obstructions to steam boat navigation because they are not high enough to allow steam-boats to pass under them, except at low water, and have no draw-spans provided.

Both bridges are located on straight reaches of the river, but the lower one crosses it at a bad angle. This, however, can be remedied by a draw span swinging up river.

The best way to remedy these bridges so as to allow steam-boats to pass them will be to put in a draw-span in each case extending across the whole channel, with the draw-pier near the west bank, and the abutment pier on or near the east bank. It would be impracticable to raise the bridges, for both are approached by trestles at present, and the high water of April, 1886, reached the lower chord.

Letters were sent, in accordance with General Order No. 9, Headquarters Corps of Engineers, Washington, D. C., October 22, 1889, to Hon. J. E. Cobb, M. C., Mr. J. M. Bridges, superintendent Alabama Central Division of the East Tennessee, Virginia, and Georgia Railroad, and Mr. A. M. Fowlkes, superintendent Birmingham, Selma, and New Orleans Railroad, appointing May 2, 1890, as the day when complainant was to meet the defendants in the U. S. Engineer Office at Montgomery, Ala., for a settlement of the matter.

On April 26, 1890, I received the following letter from Hon. J. E. Cobb, M. C., dated April 24, 1890:

"I have withdrawn complaint, and I ask that no further proceedings be had in this matter."

As Mr. Cobb has withdrawn his complaint, I deem it unnecessary to take any further action in the matter, and have written to Mr. Bridges and Mr. Fowlkes notifying them that the interview, appointed for May 2, 1890, is postponed indefinitely. * * *

It is proposed to apply the amount on hand and the appropriation asked for to the maintenance of the existing improvement, to the removal of logs and snags from the channel, and overhanging trees from the banks, and to the progressive improvement of the river channel, providing the existing legal impediments to the progress of this work shall be removed.

The census of 1880 gives for the counties bordering upon this river, within the limits of the proposed improvement, a total assessed valuation of real and personal property amounting to $9,118,034, and a total taxation of $156,526.

It is not thought that any steam-boats have made use of this river during the past fiscal year.

Money statement.

July 1, 1889, amount available	$7,801.85
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	31.50
July 1, 1890, balance available	7,770.35
Amount (estimated) required for completion of existing project	157,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	20,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

Q 12.

IMPROVEMENT OF ALABAMA RIVER, ALABAMA.

PLAN OF IMPROVEMENT.

An examination and partial survey of this river made in 1875 resulted in the adoption of a project for the improvement of the river, which provides for obtaining a channel 200 feet in width and 4 feet in depth, at low water, from Wetumpka, Ala., to its mouth, 44 miles above Mobile, Ala., a distance of 323 miles, by the removal of snags, logs, etc., from the channel, and overhanging trees from the banks; removing rock-reefs and gravel-bars by blasting and dredging, and sand-bars by works of contraction and shore protection.

The river has, generally, a movable bottom and caving banks, with numerous shoals and bars, with an average slope of about 4 inches per mile. The normal width of the upper portion of the river is from 500 to 600 feet, and of the lower portion from 700 to 800 feet; and in the portions of the river having these widths the low-water depths in the channel are from 8 to 15 feet. Where these widths have been increased, by the erosion of the banks, shoals, bars, and reefs are found. The report of 1876 specifies 116 of these as requiring improvement. An annual expenditure will be required for the removal of obstructions constantly accumulating in the channel, for the maintenance of the works constructed and for the extension of the improvement.

The original estimated cost of this improvement was $229,741. This contemplated that the improvement should be carried on continuously and expeditiously, with sufficient appropriations to provide adequate working plant. The annual appropriations have not been such as to permit the project to be carried out in this manner. It has been necessary to spend a greater part of the amount available for each year's work in removing the annual accumulation of logs and snags, due to freshets, and the original estimate must be increased by the amount so expended. An estimate of the amount required for the completion of the existing project can only be made by a re-survey of the entire river, as very considerable changes have taken place since the partial survey of 1875. No funds have been available for making such a re-survey, and this estimate is therefore omitted from the money statement.

During the past fiscal year surveys were made of six of the localities most in need of improvement, and as a result of these it is estimated that at least $75,000 can be profitably expended during the next fiscal year.

APPROPRIATIONS.

June 18, 1878	$25,000
March 3, 1879	30,000
June 14, 1880	25,000
March 3, 1881	20,000
August 2, 1882	20,000
July 5, 1884	10,000
August 5, 1886	15,000
August 11, 1888	20,000
Total	165,000

SUMMARY OF OPERATIONS TO DATE.

The average annual appropriation has thus been $13,750, and with this amount it has been practicable to build, equip, and keep in good repair an efficient steam snag-boat; to clear the channel of snags, logs, and overhanging trees, and to remove the annual accumulation of such obstructions. Jetties and dams, for contracting the channel and closing chutes, have been constructed at eight of the worst places in the river, but it has been impossible with the money available to keep them in proper repair, or to extend or modify them as required.

The following is a tabulated statement of these improvements, with their present condition:

Locality.	Distance from Montgomery.	Brush jetties.	Rock dams.	Shore end of dams.	Dams repaired in 1889–'90.	Mattresses laid.	Piles driven.	Original depth.	Present depth.	Condition June 30, 1890.
	Miles.	*L. ft.*	*L. ft.*	*L ft.*	*L ft*	*L ft*	*No.*	*L ft.*	*L ft.*	
Three Chutes....	2	.....	350	.....	.....	.....	.....	2	4	Dam broken; channel shoaling.
Cox's Bar.....	11½	.....	690	.....	160	....	616	2.5	4	Dam broken; closed with large trees, etc.
Hadnot's Bar	14	.....	600	.....	.....	....	.....	2	4.5	Dam broken; channel shoaling.
Gardner's Island.	65½	.....	910	200	.....	31	603	2	4.5	Dam broken; channel shifting.
Yellow Jack Bar	169	.....	400	.....	.....	....	.....	2.5	4.5	Good condition; channel permanent.
Hobbs's Island ..	169½	.....	435	.....	.....	....	.....	3	4	Dam broken; channel shoaling.
Haines's Island..	203	2,482	.....	.....	.....	....	.....	2.5	4	Jetty gone; channel shoaling and shifting.
Cut-off	276½	1,870	220	.....	.....	....	172	2.5	5.5	Jetty pretty much gone, dam broken up and channel rapidly closing.
Total	.....	4,352	3,605	200	160	31	1,391	.....	.....	

Navigation has been greatly benefited, and the river has been opened below the cut-off, inaccessible before the improvement, and the portion of the river below Montgomery, a distance of 294 miles, has been rendered comparatively easy and safe for navigation, except at extreme low water, at which stages the larger boats can not carry full loads.

WORK DONE DURING PAST FISCAL YEAR.

Assistant Engineer C. B. Percy, in local charge of the improvement, reports as follows:

July 1, 1889, the snag-steamer *W. J. Twining* was at work cleaning out the chute at Cloud's Bar, 90½ miles south of Montgomery, and continued working down the river to Silver Creek Shoals, 210 miles south, and finished cleaning the chute of sunken logs and snags, and the banks of overhanging trees, etc., on August 29. The river below being reported free of obstructions, the party was ordered to turn back and work over the entire river to Montgomery, which was done, and many logs and snags dangerous to navigation that had come into the channel during recent freshets, or had escaped notice on account of stage of water, were removed, also the banks of many close chutes were cleared of overhanging trees, etc., and the party arrived at Montgomery November 18.

The stage of water and the weather still remaining very favorable for work of all description, the party was ordered to make a complete examination of the river from Montgomery to the junction with the Tombigbee, a distance of 293 miles, also to

make surveys of certain specified bars and islands and to close the break in the jetty at Cox's Bar. The examination was made, several large snags and a considerable "slip in" at chute of Hobbs's Island were renewed; surveys were made of the "Aberdeen Wrecks," Carter's Shoals, lower portion of Haines's Island and river and broken jetties below, Stein's Island Chute, upper part of Hobbs's Island and river above, and Hadnot's Bar. The break, 160 feet in length, in the rock jetty at Cox's Bar was closed by depositing large sycamore trees and snags across the gap.

The usual high-water season being now near at hand, the party was ordered to Montgomery, and on December 24 all hands were discharged, and the steamer, in charge of a watchman, was laid up for the winter on the opposite side of the river.

With an average force of fifteen and three-tenths men, including the officers, working one hundred and sixty-two days, a total of 5,914 snags, overhanging trees, etc., were removed from the river and banks, and six surveys made, besides other work, as shown in tabulated statement attached.

Total distance worked over during season, 293 miles; total distance run in depositing logs, etc., from point to point, 1,157 miles; total amount of fuel consumed, 186½ cords of wood and 39½ tons of coal; time lost on account of high water, eleven and six-tenths days.

Tabulated statement of work done during fiscal year ending June 30, 1890.

Locality.	Miles below Montgomery, Ala.	Number of overhanging trees removed from banks.	Logs and drift cut upon banks.	Stumps cut level with banks.	Number of logs and snags removed from river.
Three Chutes	2	337	.....	.....	.....
The Rocks Chute	6½	251	.....	15	.....
Cox's Bar*	11½	115	.....	8	52
Hadnot's Bar†	14	.....	.....	.....	.....
Catoma Bar Chute	15	577	.....	104	1
Newport Bar Chute	28	30	.....	.....	25
Dutch Island	33½	.....	3	.....	15
Steele's Gin Landing	44	49	.....	4	1
Tyus Bar Chute	45	36	.....	4	.....
Durant's Bend	61	40	19	6	.....
Old Hell Bar Chute	64	131	44	14	26
Gardner's Island, Landing and Bar	65½ to 66½	6	.....	11	42
Tarver's Bar Chute	76½	45	19	4	161
Cloud's Bar Chute	90½	56	.....	14	39
Turkey Ford Chute	103	75	.....	.....	.....
Mary Taylor Chute	106	14	.....	9	33
White's Bluff Chute	107½	12	5	.....	47
Molette's Wood-yard	111½	.....	.....	.....	65
Middle Barter's Bar Chute	114	36	2	2	34
W. P. Molette's Landing	119	7	9	2	5
Portland Upper Bar Chute	119¾	39	14	.....	27
Park's Landing	145½	.....	.....	.....	1
Mixon's Bar Chute	147½	36	.....	.....	8
Mixon's Bar to Evans's Upper Island	.....	.....	.....	.....	3
Evans's Upper Island Chute	163	41	5	8	361
Hobbs's Island Chute†	169½	.....	.....	.....	11
Hobbs's Island to Montgomery Bar	.....	69	.....	9	20
Montgomery Bar Chute	185½	202	1	9	8
Stein's Island Chute†	191¼	688	18	20	60
Stein's Island to Bates's Island‡	.....	20	75	24	370
Bates's Island Chute	198	60	24	2	41
Bates's Island to Haines's Island	.....	.....	.....	.....	1
Haines's Island Chute†	203	247	49	30	97
Silver Creek Bar Chute	210	197	104	112	149
Claiborne Lower Landing	218¼	.....	.....	.....	1
Carter's Shoals†	243	.....	.....	.....	.....
Kelvin's Landing	260½	.....	.....	.....	2
Aberdeen Wreck Shoals†	265½	.....	.....	.....	.....
Total	.....	3,416	391	411	1,706

* A gap in jetty was closed with large trees, snags, etc.
† Survey made December, 1889.
‡ Removed from in front of Bell's Landing a wrecked and large rock bowlder.

Authority for necessary repairs and additions to the snag-boat having been granted, work was commenced March 27, 1890.

The entire machinery and boilers were overhauled and were put in thorough repair. A small upright boiler was placed in position and will be used in snagging operations when the steamer is not running in order to relieve the main boilers and save fuel. A large Deane pump for washing down bars, etc., and a portable pile-driving apparatus have been added to the plant; the hurricane roof repaired, cabin saloon repainted, also boiler, deck, and hull; the lower deck repaired and recalked, and the boat generally put in an excellent working condition.

It is proposed to apply the appropriation asked for and the small balance available, to the maintenance of the existing improvment by the removal of any recently deposited obstructions from the channel, and by making necessary repairs to the existing works of contraction, and to applying similar works to other points on the river in accordance with the approved project.

Money statement.

July 1, 1889, amount available		$13,404.92
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$8,806.97	
July 1, 1890, outstanding liabilities	2,290.21	
		11,097.18
July 1, 1890, balance available		2,307.74
Amount appropriated by act of September 19, 1890		20,000.00
Amount available for fiscal year ending June 30, 1891		22,307.74
Amount that can be profitably expended in fiscal year ending June 30, 1892		75,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

The agents of the Alabama River steam-boat lines, at Mobile, Selma, and Montgomery, and the captains of the steam-boats, have been several times requested, both orally and in writing, to furnish information as to the business done on the river. The secretary of the Commercial Club of Mobile was also requested to furnish information as to the amount of timber rafted down the river to Mobile.

The desired information has not been furnished in response to these requests, and it is therefore impossible to submit a statement of the amount of freight in tons carried on the river during the past fiscal year.

The following is a statement of the boats employed in the river trade:

Vessels.	Draught light.	Draught loaded.	Net tonnage.
Passenger and freight steamers (stern-wheel):	*Inches.*	*Feet.*	
Nettie Quill	26	5	350
Carrier	20	4	200
Maggie Burke	28	6½	475
Mary Elizabeth	20	3	100
Trade boat (stern-wheel) Minnie Lee	18	4	150
Barge Captain Sam	14	3	150
Aggregate tonnage	.....	.....	1,425

The People's Line, a company recently organized in Montgomery, will put a line of steam-boats on the river about August 15. The initial boat, now in course of construction at Wheeling, W. Va., is a stern-wheel passenger and freight steamer, to be named *Tinsie Moore*, with draught light, 20 inches, draught loaded, 5 feet, and net tonnage, 200. Also a barge, with draught light, 15 inches, draught loaded, 3 feet, and net tonnage, 150.

This line will ply between Wetumpka, on the Coosa River, and Mobile, Ala.

Q 13.

OPERATING AND CARE OF CANALS AND OTHER WORKS OF NAVIGATION ON THE COOSA RIVER, GEORGIA AND ALABAMA.

The expense of operating Lock No. 1 since March 1, 1890; of operating Lock No. 2 since March 16, 1890, and of operating Lock No. 3 since May 27, 1890, have been paid in the manner indicated by section 4, act of July 5, 1884.

In compliance with the proviso to that section, which requires the rendition of an itemized statement of such expenses, the following statement is submitted:

Statement of amount expended during the fiscal year ending June 30, 1890, *out of the general appropriation for "Operating and care of canals and other works of navigation" in operating and keeping in repair Locks Nos.* 1, 2, *and* 3, *Coosa River, Georgia and Alabama.*

Lock No. 1:		
For wages of lock-keeper	$150.00	
For supplies, paints, oils, tools, etc	14.96	
		$164.67
Lock No. 2:		
For wages of lock-keeper	125.00	
For supplies, paints, oils, tools, etc	14.67	
		139.67
Lock No. 3:		
For wages of lock-keeper	6.67	
For repairs and extra labor	.75	
For supplies, paints, oils, tools, etc	14.66	
		22.08
Total		326.42

Q 14.

PRELIMINARY EXAMINATION OF COOSA RIVER, ALABAMA, FROM THE RAPIDS AT WETUMPKA, TO CONNECT WITH THE IMPROVEMENTS ALREADY COMPLETED ON SAID RIVER ABOVE THE TEN ISLANDS.

UNITED STATES ENGINEER OFFICE,
Montgomery, Ala., November 24, 1888.

GENERAL: In compliance with Department letter of September 29, 1888, I have the honor to submit the following report of a preliminary examination of the Coosa River, Alabama, from the rapids at Wetumpka to connect with the improvements already completed on said river above

the Ten Islands, as required by the river and harbor act of August 11, 1888.

A survey of this river was made in 1870–'71, between Wetumpka and the Selma, Rome, and Dalton Railroad Bridge, together with a reconnaissance from this point to Greensport above the Ten Islands. In 1872 a partial instrumental survey was made covering the limits of this reconnaissance, and in 1878 another partial survey of the river between Wetumpka and the Selma, Rome, and Dalton Railroad Bridge. While the data remaining from these surveys afford material for a preliminary report, they are not sufficient for an accurate estimate of cost of the improvement proper to be made. In my opinion this river is worthy of improvement; and the cost of a survey which is necessary for the report contemplated by the act, including a project with estimate of the cost of the improvement, will be $6,000.

This river is now under improvement by the General Government between Rome, Ga., and the Selma, Rome and Dalton Railroad bridge. The approved project for the work contemplates a minimum depth of 3 feet in the channel at low water. The natural river channel is made available simply by removing obstructions wherever the fall of the water surface is not too great; and where rapids occur, which could not be made navigable in this way, locks and dams are constructed for passing them. The locks have a width of 40 feet and a length of 210 feet between miter-sills. They are of ample capacity to accommodate existing navigation of this river. Three of these have been constructed, each in connection with a dam, and these, together with a dam without lock at the lower end of Broken Arrow Shoals, will afford navigation from Rome, Ga., to the Coosa coal-fields at Broken Arrow. These locks will be completed and put in working order with appropriations already made. The system of navigation so completed will be in harmony with the original project for steam-boat navigation.

Broken Arrow Shoals, the lower limit of the existing improvement, is the starting-point for down-stream navigation between the Coosa River coal-fields and the Gulf. It is probable that a modification of the existing project for the improvement of the Coosa River will be necessary to adapt this improvement to the economical transportation of coal and iron. This will require the construction of locks of greater capacity and a system of continuous slackwater navigation in place of the alternation of natural river and slackwater navigation now nearly completed for the upper section of the Coosa. In view of the increased cost of such modification, and of the depth now available upon the Alabama, it may be found desirable to complete the improvement of this river to Wetumpka, Ala., for steam-boat navigation similar to that of the upper river, building the locks of the increased size required for a future modification of this system, and building for the present only as many as may be necessary to give, in connection with navigable sections of the natural river, the present minimum 3-foot depth of channel. In that case the construction of other locks and dams and raising the crest of the dams first constructed would follow to effect the change of system to continuous slackwater navigation with a minimum depth of, say, 6 feet. All work would be planned as part of the ultimate project. The survey must contemplate the final improvement.

From Broken Arrow Shoals to Wetumpka the Coosa River has an estimated total fall of 328 feet. Over this distance there are local slopes so great as to necessitate the use of thirty-three locks and dams. The remainder of the river, it has been estimated, may be given a suitable channel for navigation with a minimum depth of 3 feet at low water by the

removal of rock obstructions. A rough estimate of the cost of removing these obstructions amounts to $436,000. The thirty-three locks and dams required between Broken Arrow Shoals and Wetumpka, if built of same dimensions as those already constructed, with an average lift of 8 feet and guard of 8 feet, would probably cost $3,630,000. The total cost of continuing the improvement of this river upon the same plan from the improvements already completed to Wetumpka is thus about $4,066,000, roughly estimated.

If the locks are made of the increased dimensions, which seem to be desirable, the additional cost would be about $1,782,000.

For a complete system of continuous slackwater navigation with minimum channel depth of 6 feet and having locks 52 feet wide and 320 feet between miter sills, the cost may be roughly estimated as follows:

Thirty-three locks and dams having an average lift of 10 feet and guard of 8 feet (or their equivalent), at $190,000 each	$6,270,000
Removal of rock obstructions (uncertain)	400,000
Total	$6,670,000

It seems more probable that the foregoing rough estimates will be reduced by a careful survey than that they will be increased. Until definite locations of locks and dams are decided upon, the precise number can not be stated. If continuous slackwater navigation be preceded by the completion of 3-foot navigation with locks of increased dimensions, the simple expedient of raising the dams will probably contribute largely to the completion of continuous 6-foot slackwater navigation. Whether a progressive development of the 6-foot slackwater navigation will materially increase the cost of the latter can only be determined after the completion of detailed surveys. The inauguration of 6-foot navigation upon the Coosa must be followed by a corresponding improvement of the Alabama.

The public necessity and convenience that may be subserved by the contemplated improvement of the Coosa River have been stated at length in a memorial addressed to the Congress of the United States by the Coosa River Improvement Convention, assembled at Montgomery, Ala., March 15, 1887. From this source I present the following statement of facts and deductions therefrom which I believe to be substantially correct. The convention comprised the representative business men of Alabama, and was presided over by the Hon. Thomas Seay, Governor. The memorial was prepared by a committee of fifteen gentlemen whose names are a sufficient guaranty of conscientious performance of the duty intrusted to them.

There are nine counties in Alabama, lying immediately upon the Coosa, and cut off from all water communication with the Alabama, to wit: Elmore, Chilton, Coosa, Shelby, Talladega, St. Clair, Calhoun, Etowah, and Cherokee.

These counties have a population of over 150,000 souls. They have in cultivation nearly 700,000 acres of land. Their territory covers nearly 1,500,000 acres. The assessed valuation of their property is over $13,000,000. They produce 75,000 bales of cotton, valued at $3,000,000. They produce over 3,000,000 bushels of corn, and nearly 500,000 bushels of wheat. They grow annually over 60,000 pounds of tobacco.

If the people of these counties had cheap and uninterrupted river navigation the growth of cotton, tobacco, and the cereals would be vastly increased. Over one-third of their lands is open and in cultivation. The remaining two-thirds is covered with a virgin forest, capable of supplying Mobile with timber for exportation long after the forests adjacent to the Gulf have been denuded.

These forests extend over 1,000,000 acres, and contain not less than 3,000 feet to the acre, or a total of 3,000,000,000 feet of lumber, whose gross value may be placed at $30,000,000. The total value of fields and forests is $43,000,000. The annual present value of farm products is not under $6,000,000. The counties immediately upon the

Coosa River at present have iron furnaces whose capacity is not less than 175,000 tons per annum, and the value of whose output is $2,500,000 per annum. They have in process of erection other furnaces which will turn out 1,000 tons per day, giving an annual output valued at over $3,000,000.

The furnaces now in operation and those in process of erection represent a capital of $2,000,000, and offer employment to 2,000 men, representing a population of 10,000 people.

The combined valuation of fields, forests, and present capital in furnaces and mines of these nine Alabama counties will reach $50,000,000.

In addition to these products the Coosa River counties are rich in other mineral products. Lead and copper are found at various points near the river. Marble and limestone are abundant. Talladega marble is noted as rivaling in beauty and purity the most celebrated marble of Italy. Gold is found in Coosa County and elsewhere. At one time the gold mines of that section attracted a large population. The purest kaolin is found in Calhoun and Coosa. Mica appears in Chilton. Red and yellow ocher is found in Elmore. Slate and granite and sandstone are abundant in Talladega, Calhoun and Shelby. Plumbago exists in Chilton, Coosa, and adjoining counties. Tin has been discovered in Clay and Coosa counties. Emery, asbestos, fire-clay, flagging stone, manganese, marls, millstones, phosphates, pyrites, zinc, and other material have been found by the State geologist, Dr. Eugene Smith, very generally distributed throughout this mineral region.

That part of the Coosa that lies in Georgia has tributary to it all the country between Lookout Mountain on the northwest and the line of hills or mountains embracing the gold belt on the southeast, traversed by the valleys of the Chattooga, Conosowage, Coosawattee, Oostenaula, and Etowah, rivers, and Big Cedar Creek and their tributaries, all whose waters help to form the Coosa.

This region embraces a population of over 175,000, and an area of 6,000 square miles of productive soil and unsurpassed mineral resources. It produces good upland cotton, the cereals, tobacco, and fruit.

The annual products of the Coosa Valley from Rome to Wetumpka are:

Wheat	bushels..	2,125,000
Corn	do....	3,500,000
Oats	do....	250,000
Cotton	bales...	100,000

These, with other farm products, give an annual agricultural yield of over $10,000,000.

* * * * * * *

The Coosa region is densely timbered with hard woods. The white-oak region of the Chattanooga range covers 500 square miles and includes part of the Coosa counties.

Large beds of limonite or brown iron-ore exist in Floyd and other adjacent counties, and have been extensively worked. Bituminous coal is found everywhere contiguous to these streams. Copper has been found in Murray County. Important deposits of silver, associated with lead, copper, and gold, exist in Murray County. Ocher is found along the Etowah River. At the western base of the Cohatta, in Murray County, lead has been found. Slate, building stone, marble, sandstone, and flag-stone are found generally in these counties.

Such is this Coosa Valley, landlocked as it is at present, and dependent for a market upon the railroads which cross it at wide intervals.

COAL DEPOSITS OF THE COOSA VALLEY.

James Noble, sr., in a letter to Governor Smith, of Georgia, says:

"The coal in the Coosa Valley extends over a large area of country. It is of excellent quality for any purpose and easily mined. This coal-bearing region is about 22 miles from Selma, Rome and Dalton Railroad, but very near to the Coosa River. Its extent I can not tell, because I do not believe it has ever been thoroughly explored."

The Lookout coal-field in Georgia is about 40 miles long and varies from 5 to 12 miles in width. The mountain extends from Chattanooga to the Coosa River at Gadsden, upwards of 80 miles.

Mr. C. W. Howard, in a letter to Governor Smith, of Georgia, says:

"I do not know the number of coal seams in the mountain, but it is great. In some portions of the mountain, both the Upper and Lower Carboniferous formations exist. In these instances the number of seams is of course increased. I have seen the coal on the surface exposed by the plow or on the roots of trees which have been blown down, and also at the base of the mountain, more than 1,000 feet below the plateau above. The seams which have been exposed vary in thickness from 10 inches to 7 feet. The quality of the coal is not surpassed by any bituminous coals of the United States. This statement is based both upon ample practical test and by scien-

tific analysis—twice by eminent chemists in Philadelphia. It will be observed that this coal formation runs down to the very bank of the Coosa River."

During the late war it was proved by experiment that the very best quality of coking coal is to be found in the Coosa Valley. At Broken Arrow on the river, the basin between Daughdrill's Mountain on the east and Bald Rock Mountain on the west is 5 miles wide. Between these two mountains are two intermediate ridges. The mining for river shipment has been done chiefly on Broken Arrow Creek and its tributary, known as No Business Creek. Here is a seam of coal 4 feet 2 inches thick. Visiting that point on his survey of the Georgia Pacific Railroad, Mr. John Campbell, professor of chemistry and geology at Washington and Lee University, said:

"We also saw the coal freshly thrown out of the pit at another opening, and a more beautiful, black, shining coal one would not desire to see. It is columnar in structure and rather friable for stocking, but exactly suited to coking. We observed neither slate nor sulphur in this coal. This seam is manifestly one of great value."

Professor Tournney, in his State report, says that he found two seams on Broken Arrow Creek, each containing 5 feet 2 inches of clear coal. Mr. T. H. Aldrich, as reported in Professor Smith's report for 1875, says of this field, that there are three seams known, the thickness of which are 3 feet, 3½ feet, and 4 feet. It is reported that Major Howell found a 9-foot seam in the Coosa field.

IRON DEPOSITS OF THE COOSA VALLEY.

No adequate conception can be formed of the extent and value of iron ore within easy reach of the Coosa River. An unbroken ridge called "Shinbone" extends along the eastern base of Lookout Mountain for more than 80 miles. For that whole distance it is an unbroken vein of iron ore. It is never more than a mile from the base of Lookout Mountain, in which coal is found, and all the way, side by side for those 80 miles coal, iron ore, sandstone, fire-clay, limestone, and extensive forests are in juxtaposition.

In the Coosa Valley, lying northeast of Cahaba coal-field and east of Lookout Mountain, are many fine beds of ore. On the western side of the valley mines are worked near Springville and Attala, at the entrance of Wills Valley. Farther to the east are two red ore ridges running parallel to each other, and east of Ashville, St. Clair County, with a northeastern trend, not yet mined.

East of the Shinbone Ridge are other red ore ridges extending from Round Mountain, in Cherokee County, to Georgia, worked at Round Mountain and Gaylesville, in Cherokee County.

In the Red Mountain, St. Clair, Jefferson, and Shelby counties, red hematite is to be found in four veins of from 4 to 22 feet in thickness.

Limonite or brown ore, which is preferred by some of the furnaces, is more widely diffused throughout North Alabama in all the regions extending southward towards the Alabama River. The greater part of it is mined in Bibb, Calhoun, Cherokee, Etowah, and Talladega counties. The brown ore is used altogether in the charcoal furnaces, and in the coke furnaces the limonite and hematite are sometimes mixed.

Magnetic iron ore is found throughout the iron district.

The following gives the average amount of metallic iron and other constituents found in these varieties of iron:

Red iron ore—hematite:

	Per cent.
Metallic iron	41 to 51
Silica	16 to 30
Lime	20 to 40
Phosphorous	0.22 to 0.50

Brown iron ore, limonite:

Metallic iron	40 to 57
Silica	12 to 40
Phosphorous	0.03 to 2.50

The valley of Choccolocco Creek, which flows into the Coosa from the east in the northern part of Talladega, is rich in ore. Professor Campbell says: "The comparative ease with which they (the ores) can be mined, their proximity to good furnace sites along Choccolocco Creek, which furnishes ample supplies of water at all seasons, the abundance of limestone near at hand, the presence of extensive forests that can be utilized for making charcoal, and the facilities for transporting coal, which are now operated, all contribute to make this a most attractive region for those who have capital and enterprise to invest in the manufacture of iron."

Anniston Valley is a branch of the great Silurian Valley of the Coosa. It presents another extensive iron-ore region. The ores that supply the furnace at Anniston are mined on a large scale on both sides of the valley. Southwest of Oxford—in fact

within the limits of the town—the Anniston and Choccolocco ore belts coalesce and extend into Talladega County, where they furnish ample supplies for the Alabama furnace.

Daughdrill's Ridge, a short distance north of Broken Arrow Creek, is covered with floating limonite ore, "thousands of tons of which could be gathered up from the surface within a short distance," says Professor Campbell.

The Anniston district embraces the furnaces and iron region on each side of the Selma, Rome and Dalton Railroad, from Cave Springs, Ga., to Montevallo, Ala., as well as the remarkable iron deposits along the line of the Anniston and Atlantic Railroad for 50 miles south of Anniston. This region, says the United States Chief of the Bureau of Statistics, "is the center of one of the richest iron regions in the South."

This district now embraces:

		Tons.
Etna Furnace, capacity	per day	20
Cherokee Furnace, capacity	do	50
Tecumseh Furnace, capacity	do	50
Stonewall Furnace, capacity	do	25
Rock Run Furnace, capacity	do	35
Woodstock (2) Furnaces, capacity	do	100
Clifton (2) Furnaces, capacity	do	85
Shelby (2) Furnaces, capacity	do	100
Brierfield Furnace, capacity	do	25

This gives a total of twelve furnaces, with an output of 490 tons daily, or over 175,000 tons annually.

Every ton of this iron, either in pig or wrought into valuable fabrics, should find its way to market by way of Mobile. The water transportation to the Gulf and the ocean transportation to eastern markets will be so much cheaper than by railroad, that not only the iron of the Coosa River, but also a great part of that of the Cahaba and Birmingham output, will find an easy and profitable outlet by way of Mobile.

The iron output of furnaces in Alabama has been as follows:

	Tons.
In 1876	25,000
In 1880	77,000
In 1885	227,000
In 1886	283,859

That district of Georgia which lies convenient to the Coosa River had, in 1885, an output of 32,924 tons.

The present iron production of the Coosa Valley region, extending from the neighborhood of Calera to Rome, Ga., is not much, if at all, below 200,000 tons.

The total iron production of the United States in 1885 was 4,529,869 tons. There had been very little increase since 1880. But in that time the output of Southern furnaces had grown from 397,301 tons to 712,837. The most remarkable increase was in Alabama.

It is now conceded that the Alabama output will constantly grow in volume, since iron can be made cheaper here than elsewhere in the United States. If now we furnish transportation so cheap that we can at Mobile undersell any point upon our coast, the result must be that Alabama in a few years will furnish millions of tons for market, and the greater part of it would pass down the Coosa River.

LOCAL IMPORTANCE OF THE WORK.

By the removal of obstructions to navigation the $60,000,000 of assessed values would speedily grow into hundreds of millions of actual values, and the $10,000,000 of present products would sink into insignifience when compared with future possibilities.

The cotton fields, instead of growing only 100,000 bales, would soon double their yield. The growth of cereals would be only limited by the demand of Montgomery, Selma, Mobile, and the country dependent upon these markets.

The Coosa Valley is an excellent wheat country. Every bushel of wheat of which it is capable should be ground into flour by mills driven by the water-power of the Coosa dams, and every barrel of flour now sold by Montgomery, Selma, and Mobile should be the product of such mills.

In estimating the commerce of Montgomery and Selma, in the absence of statistics from these cities, we may safely say that their united commerce in the ratio of population about equals that of Mobile. The city of Mobile sells 100,000 barrels of flour. The three cities sell not less than 200,000, of the value of perhaps $1,000,000 annually.

This $1,000,000 worth of flour should and can be shipped by the Coosa River. These cities import from the West over 1,000,000 bushels of corn, all of which should be brought to them by the Coosa improvement.

NATIONAL IMPORTANCE OF THE WORK.

But it is not alone the markets within the State of Alabama that would be the beneficiaries of this economy. The city of New Orleans now consumes 363,000 tons of Pittsburgh coke and 59,000 tons of Alabama coal, a total of 422,000 tons. With the Coosa opened these 422,000 tons, which now cost the consumer not less than $1,700,000, can be sold for less than $1,000,000.

The water-power that would be developed by the dams of the Coosa River would be speedily sought for all manner of factories. The erection of cotton and flouring mills and tobacco factories would be as certain as that the products are there and the power is there.

Cheap coal and iron would result in the building of furnaces all along the river, the encouragement of ship-building, and the establishment of iron and steel works at Montgomery, Selma, and Mobile.

The iron and coal fields would find at Mobile an adequate market for the utmost business of which they are capable. With coal sold there as low as $2 per ton they would successfully compete with all the world. Coal and iron would find a market all along the coast of the United States, around the borders of the Gulf of Mexico and throughout the West Indies. It would supply the shipping that seeks Panama.

Hon. A. K. McClure, of the Philadelphia Times, in his recent letters from Mobile to that journal, gives an accurate summary of the situation:

"Mobile is one of the few important natural gateways to the world of waters in the South, and second only to the Mississippi outlet in the industry it should inspire and the commerce it should command. The beautiful bay on which Mobile is situated has tributaries reaching far into almost boundless sources of natural wealth, which at no distant day will build up one of the grandest empires of the new South. * * *

"With water transportation from the immense coal-fields of Alabama, and Mobile Harbor completed for the largest shipping, no State in the Union and no nation of the world will be able to compete with this State in supplying the Gulf of Mexico, the West Indies, and Central and South America with coal. England now draws some $4,000,000 annually from those countries for coal, while the United States draws little more than $250,000, and the supremacy of Mobile as a cotton center would be more than restored. Mobile would be literally the great gateway to the waters of the world for the southern coal trade if given the benefits of the gifts nature has bestowed upon her; and what interests or what section can assume to hinder so great a consummation? There are 4,000 square miles of virgin pine forest, with large supplies of cypress and white oak, which would be made marketable by these completed water-ways, and the cotton belt of Alabama and eastern Mississippi, that sought Mobile before the war, produces over 1,000,000 bales annually. These are stubborn facts, facts which the people of Mobile are worshiping as the early salvation of both city and State; facts which the people of Pennsylvania and the North must look in the face soon, at the latest, and the sooner the better. They foreshadow the same mutations in industry, trade, and wealth which have left their inexorable lessons on all ages and people of the past, and I welcome them as certain to give luster to another of the many unpolished jewels of the Republic."

The distance from Gadsden on the Coosa to Guntersville on the Tennessee is only 35 miles. Major McFarland, of the Corps of United States Engineers, in his report to the Chief of Engineers in 1872, reports that a canal can be cut between the two rivers at those points. Following the creeks the route would be about 51 miles. He puts the cost at $11,570,607, based upon the prices for labor and material as they were in 1872.

* * * * * * *

The opening of the Coosa and her connection with the Tennessee would empty into the bay of Mobile, by an easy and cheap water-route, the agricultural and mineral wealth of immense stretches of country, now shut out from the sea except by costly railroad transit or by the 3,000 miles of water-route via the mouth of the Tennessee and the Mississippi. It would open to its natural and nearest sea-port one-fifth of the State of Alabama, a large section of north Georgia, and the whole sweep of the Upper Tennessee, with her score of important tributaries.

It would offer at Cairo a new mouth to the Cis-Mississippi Valley and invite into its avenue of escape the millions of tons of grain which every year seek in vain an outlet to the sea. The rail routes eastward are choked with freights. The railroad tariff west of St. Louis is prohibitory. The jetties at the mouth of the Mississippi render that river a better avenue for commerce than formerly, but can not obviate the ice gorges that obstruct the Upper Mississippi. At no time would the Coosa route

be obstructed by ice, but throughout the year the products of an immense region, stretching from the borders of Virginia and North Carolina to the Ohio River, would be emptied into Mobile Bay. .This region south of the ice gorges produces millions of tons of grain and is rich in coal and iron of the best quality and in most convenient position for mining.

The national importance of this line will be understood from a glance at the mineral deposits of the region through which it passes and the facility offered those deposits for transportation to the sea, additional outlet afforded to the superabundant grain of the West, and the communication furnished the shipping of the Western waters and those of the Gulf for easy and cheap and safe intercourse.

This line would offer at Rome, Ga., a secure arsenal, protected by mountains, remote from the sea and surrounded by the crude materials for war. Transports could pass from the Ohio on one side and the mountains of southwest Virginia on the other directly to Mobile Bay. The Gulf coast will always be the favorite, because supposed to be the weakest point of attack for a foreign foe. When large armies assemble to meet invasion in this quarter, open water channels connecting the Gulf with the Western rivers will be a military necessity. * * *

SUMMARY.

* * * * * * *

The Coosa River presents the cheapest and most certain water-route to the Gulf of Mexico of the coal, iron, cotton, and cereals of a vast extent of country.

The removal of the obstructions which cut in half this river, now navigable for hundreds of miles below and above such obstructions, is a national duty, in view of the commerce it would pour into the Gulf of Mexico. The opening of the Coosa would enable the Government to move munitions of war from the interior to the seaboard safely and expeditiously.

It would place the navigable waters of the Coosa so close to the navigable waters of the Tennessee that water communication between the two streams must certainly follow, and thus afford the Tennessee River and its vast tributaries an outlet to the Gulf by way of the Bay of Mobile.

* * * * * * *

Very respectfully, your obedient servant,

R. L. HOXIE,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

SURVEY OF COOSA RIVER, ALABAMA, FROM THE RAPIDS AT WETUMPKA TO CONNECT WITH THE IMPROVEMENTS ALREADY COMPLETED ON SAID RIVER ABOVE THE TEN ISLANDS.

UNITED STATES ENGINEER OFFICE,
Montgomery, Ala., December 30, 1889.

GENERAL: Section 13 of the river and harbor act of August 11, 1888, provides that—

The Secretary of War is hereby authorized and directed to cause a survey to be made at the earliest practicable time for the location of a channel in and along the Coosa River in Alabama, from the rapids at Wetumpka to connect with the improvements already completed on said river above the Ten Islands, and to direct the engineer making the survey to report as to the most feasible, economical, and suitable plan for making such improvement.

On November 24, 1888, Capt. R. L. Hoxie, Corps of Engineers, submitted the preliminary report required by section 14 of the same act, in which he stated that in his opinion the river was worthy of improvement and that the required survey would cost $6,000. On January 17, 1889, I relieved Captain Hoxie of the duties then in his charge, and the charge of the survey having thus devolved upon me, I have the honor to submit the following report:

Letters of March 12 and 26, 1889, from the office of the Chief of Engineers, allotted $6,000 for the survey, and preparations were made to

send out a surveying party as soon as the water in the river became low enough to permit a useful survey to be made. Assistant Engineer Charles Firth was placed in charge of the party, which began the survey early in May at Lock 4, 3½ miles above the crossing of the Georgia Pacific Railway, and completed it at Wetumpka about November 1, 1889.

The accompanying report of Mr. Firth contains a statement of the method of survey and a detailed description of that part of the river surveyed, of the obstructions to navigation, and the methods of improvement suggested for each locality. The report, with its table of distances, locks and dams, and estimates, has been prepared under my personal supervision and expresses my views as to the methods of improvement and their cost, and I will not therefore repeat the details. I regret that a map and profile of the portion of the river surveyed does not accompany this report; but as the report was required at as early a date as practicable, it was not advisable to defer it until the field maps and profiles—drawn with pencil—by the aid of which the report has been prepared could be replotted on a reduced scale in proper form for transmission. The map and profile will be forwarded as soon as they can be completed. In the mean time, to make my report clearer, I attach a "map* of the river system of Alabama and its basin," published with the memorial of the Coosa River Convention, assembled at Montgomery, Ala., March 15, 1887.

GENERAL DESCRIPTION OF THE RIVER.

The Conasauga and Coosawattee rivers rise in northwestern Georgia, and by their junction, about 4 miles above Resaca, Ga., form the Oostenaula, which then flows to the southwest until it is joined by the Etowah, about 4 miles above Rome, Ga., forming the Coosa River. The Coosa River thence has a general direction west by south to near Gadsden, Ala., where it turns to the southward. Eleven miles below Wetumpka, and 18 miles above Montgomery, the Coosa and Tallapoosa meet and form the Alabama River, which, 312 miles lower, is joined by the Tombigbee, and then becomes the Mobile River, which empties into Mobile Bay at Mobile, 44½ miles below.

The Oostenaula and Coosawattee Rivers have been improved by the Government from Carter's Mill, Ga., to Rome, by the excavation of rock and gravel shoals and the building of wing-dams, etc. The Coosa River from Rome to Greensport has been similarly improved and is now in fair condition, and a line of steam-boats makes regular trips at all seasons between Rome, Ga., and Gadsden, Ala., and will extend the route to landings below as soon as the three locks at Whistenant's and Ten Island Shoals are opened. These three locks are nearly completed and will be opened to navigation this winter, and a fourth lock and dam have been begun below Broken Arrow Shoals. The completion of the dam at Lock 4 will enable boats to reach the Coosa River coal fields, which lie between Locks 3 and 4, and will afford the manufacturing towns on the upper river the benefits of cheap water transportation for their coal. Between Lock 4 and Wetumpka no improvements have been made and the river is not navigable. From Wetumpka to Mobile, the Alabama River has been improved by the Government by the removal of logs and snags and the building of wing dams, etc., and is now in fair boating condition at all seasons of the year. Regular lines of large steam-boats trade between Montgomery and Mobile. The Government maintains a steam snag-boat on the Alabama River.

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* Omitted; printed in House Ex. Doc. No. 94, Fifty-first Congress, first session.

The improvement of that portion of the Coosa River under consideration would open to continuous navigation the following mileage:

	Miles.
Oostenaula and Coosawattee rivers, Georgia, (105 miles):	
Carter's Mill, Georgia (Coosawattee River), to Resaca (on Oostenaula River, 4 miles below the junction of Coosawattee and Conesauga rivers)	45
Resaca to Rome, Ga., (on Coosa River, 4 miles below junction of Oostenaula and Etowah)	60
Coosa River, Georgia and Alabama, (315 miles):	
Rome, Ga., to Greensport, Ala., (29 miles below Gadsden)	162
Greensport to Lock 4	26
Lock 4 to East Tennessee, Virginia and Georgia (formerly the Selma, Rome and Dalton) Railroad bridge	48
East Tennessee, Virginia and Georgia Railroad bridge to Wetumpka	68
Wetumpka to junction with Tallapoosa River	11
Alabama River, Alabama (312 miles):	
Junction of Coosa and Tallapoosa rivers to Montgomery, Ala	18
Montgomery to junction of Alabama and Tombigbee rivers	294
Mobile River, Alabama (44 miles):	
Junction of Alabama and Tombigbee rivers to Mobile, Ala	44
Total	776

From this it will be seen that there are stretches of 293 miles of navigable river above Lock 4 and of 367 miles below Wetumpka, and that the proposed improvement of the 116 miles between Lock 4 and Wetumpka would afford a continuous route of water transportation—776 miles in length—from northwestern Georgia through the mineral region of North Alabama to the Gulf of Mexico at Mobile, Ala.

Of this 116 miles, the improvement of the upper 48 miles (from Lock 4 to the East Tennessee, Virginia, and Georgia Railroad bridge) has already been authorized by law, the appropriations heretofore made for the Coosa River amounting to $523,700, with which the river below Rome has been improved, and Locks and Dams 1, 2, and 3 built, and Lock 4 begun, having been designated as made for the improvement of that part of the river between Rome, Ga., and the East Tennessee, Virginia, and Georgia Railroad bridge. To complete the authorized improvement of this section four additional locks and dams will be required, and are included in the estimates submitted herein.

It is therefore only necessary to extend the sanction of law to the improvement of 68 miles of the Coosa River between the bridge and Wetumpka to enable this fine water-route from the coal, iron, and timber fields of north Georgia and Alabama through the rich agricultural and timber regions of middle and south Alabama to the Gulf of Mexico to be eventually opened to commerce.

FORMER SURVEYS, REPORTS, ETC.

As early as 1823, the legislature of the State of Alabama passed "an act to improve the navigation of Coosa River and to aid in its connection with the Tennessee waters," and in 1824 this act was formally approved by Congress.

In 1828 Congress provided that any surplus of the grant for improving Tennessee River should be applied to the improvement of the navigation of the Coosa, Cahaba, and Black Warrior rivers.

I have not been able to learn what was done under these acts, but it is known that steam-boats have been plying on the Upper Coosa for some forty years, and that a channel was partially cleared through the shoals in the lower river, by which flat-boats, carrying cotton to Mobile, were floated down.

In 1870 an instrumental survey from Wetumpka to the East Tennessee, Virginia and Georgia Railroad Bridge, and an examination thence to Greensport, was made by Assistant Engineer H. C. Fillebrown, under the direction of Col. J. H. Simpson, Corps of Engineers.

Colonel Simpson's report of the examination between the bridge and Greensport is printed in the Annual Report of the Chief of Engineers for 1871. . The estimates provide for five locks (size not stated), to be built of crib-work, with rubble masonry head and tail walls, and rock and gravel excavation for a 3-foot channel through shoals, at a total estimated cost of $278,484.50.

The report of Col. Walter McFarland, Corps of Engineers, on the instrumental survey of 1870 from Wetumpka to the bridge, is printed in the Report of the Chief of Engineers for 1872. The estimates provide for twenty-nine locks, each 40 feet wide by 200 feet between miter-sills, built of crib-work, with masonry head and tail walls, and rock excavation for a 3-foot channel through shoals, at a total estimated cost of $1,923,020.

In 1872 an instrumental survey from the East Tennessee, Virginia and Georgia Railroad bridge to Greensport was made, under the direction of Colonel McFarland, by Assistant Engineer J. C. Long, whose report is printed in that of the Chief of Engineers for 1872. The estimates provide for eight locks—size not stated—built of crib-work, sheathed with plank, with masonry head and tail walls, and for rock and gravel excavation for a 4½-foot channel through the shoals, at a total estimated cost of $470,668.

In 1874 an examination from Rome, Ga., to Gadsden, Ala., under the direction of Colonel McFarland, was made by Assistant Engineer B. W. Frobel, whose reports are printed in Report of the Chief of Engineers for 1875. The estimates provide for one lock, 200 by 32 feet, 3 feet lift, to be built of crib-work, with masonry head and tail walls, and for the excavation of rock and gravel to provide a channel 80 feet wide and 4 feet deep through the shoals, at a total estimated cost of $180,000.

In 1878 a resurvey of Whistenants and Ten Island Shoals below Greensport was made by Assistant Engineer R. C. McCalla, under the direction of Col. W. R. King and Capt. W. L. Marshall, Corps of Engineers. The report by Captain Marshall is printed in the report of the Chief of Engineers for 1878. It recommends the construction of three "locks, to be of masonry; the water side and miter-sills to be laid in cement, and also the land side in the vicinity of the hollow quoins, for a distance back from the hollow quoins and along the face of the lock of 10 feet. The rest of the lock-masonry to be of dry stone. The coping, hollow quoins, facing of the miter-sills, and the side of the lock-chamber from water surface of lower level at low water to the coping, to be of cut stone, the rest of rubble. The lock to be 210 feet between miter-sills and 40 feet wide, to accommodate the steamers which now navigate the Upper Coosa. The reefs to be excavated to a depth of 3 feet at extreme low water, or 4 feet at ordinary low water, and for a channel width of 80 feet." The estimate of the total cost of the improvement at the two shoals, including the accessory dams and dikes, was $155,616.23.

In 1879 an instrumental survey from Wetumpka to the foot of Tuck-a-league Shoals, and a reconnaissance thence to the East Tennessee, Virginia and Georgia Railroad bridge, was made by Assistant Engineer G. B. Yuille, under the direction of Maj. A. N. Damrell, Corps of Engineers, whose report is printed in that of the Chief of Engineers for 1881. The estimates provide for the construction of thirty-one locks—each 210

by 40 feet—between Wetumpka and the bridge; each "lock to be built of stone masonry; the miter-sills, hollow quoins, and chamber walls in vicinity of quoins and coping to be of cut-stone masonry laid in cement; the chamber-walls on water side and the piers of head and tail bays of lock-chamber to be of rubble masonry laid in cement; the chamber wall on land side to be mostly of dry stone masonry."

The total estimated cost of the improvement for a channel 4 by 80 feet, including the accessory dams and dikes and rock excavation through shoals, is placed at $2,649,949.

The first appropriation, "for the improvement of the Coosa River, Georgia and Alabama, between Rome and the Selma, Rome and Dalton Railroad Bridge," was made by the act of August 14, 1876. The appropriation was $30,000. All subsequent river and harbor acts have contained appropriations for this object, the total now amounting to $523,700. With this amount, the river between Rome and Greensport was placed in fair boating condition at all seasons by 1880; the three locks and dams at Whistenants and Ten Island Shoals, as projected by Captain Marshall, have been nearly completed, and a small amount of work has been done on a fourth lock and dam below Broken Arrow. It will be seen that the cost of the work has considerably exceeded the estimates. This is accounted for in the annual reports of the officers in charge for 1880 and 1888, as due to the better quality of work adopted for the locks, which have been built throughout of masonry laid in cement, with cut stone for the inner faces of both side walls, and to the fact that the cost of foundations, building stone, and of labor and material generally, were higher than when the original estimates were made.

PHYSICAL CHARACTERISTICS.

Between Lock 4 and Wetumpka the river flows through a rich mineral, timber, and agricultural region. Much of the land bordering its banks has already been brought under cultivation, and as soon as the land is cleared of its timber it is immediately converted into productive farms.

The total fall in the low-water surface of the river in this distance of 116½ miles is 322.73 feet, or an average of 2.77 feet per mile. In its physical characteristics this portion of the river may be divided into two sections, the upper, from Lock 4 to the head of Weduska Shoals, a distance of 68.73 miles; the lower from this point to the foot of the Wetumpka Rapids, a distance of 47.6 miles. The fall in the upper section is 77.76 feet, or a little more than 1.1 feet per mile; and in the lower 244.97 feet, or 5.1 feet per mile.

The fall in both sections is so unevenly distributed, varying from less than 0.1 foot per mile in some of the pools to nearly vertical falls of 1 to 3 feet in some of the shoals, as to preclude the possibility of applying to either section any system of improvement other than that of providing for slack-water navigation by means of locks and dams.

The profile of the natural river at low water exhibits a succession of deep pools, varying in length from one-half mile to 8 miles, separated by shoals formed by ledges of solid rock or loose stones and detached bowlders, which frequently rise above the surface. The shoals extend along the river for distances varying from a few feet to 12 miles, and have depths of water varying from a few inches to several feet. The total length of the pools is 42 miles and of the shoals and reefs 26½ miles in the upper section, and in the lower section the pools have a total length of 19 miles and the shoals and reefs 29 miles.

The bottom of the river throughout is rocky, composed of solid

ledges or loose rocks and bowlders, with an almost total absence of sand or gravel bars.

The normal width of the river at low water is from 600 to 800 feet. At "The Narrows" it contracts to 400 feet, with a depth of over 85 feet. The greatest width is 3,700 feet at Butting Ram Shoals, where the water is very much dispersed, and the river-bed is an intricate mass of rocks, reefs, and islands.

The heights of floods above low water, of course, vary greatly at different points, corresponding to variations in the widths and slopes of the river. The flood of 1886 was much the highest ever known. During this flood the greatest rise was 53 feet at Wetumpka and the least 5 feet at Butting Ram Shoals.

Islands are very numerous in all parts of the river, especially so in the lower section. They vary in area from a few feet to 70 acres. The larger are mainly in the upper section, and are generally cultivated.

In the upper section the banks are alluvial, and the bottom lands, which are generally under cultivation, are from a few feet to more than a mile in width. These lands are not overflowed in ordinary floods.

In the lower section there is but little bottom land, the river flows between high hills, and the banks are steep and rocky; in many places formed of solid rock, rising almost vertically from the water.

Suitable stone for first-class lock masonry is found in both sections—in the upper, blue limestone, and in the lower, gneiss.

A number of creeks of considerable size enter the river between Lock 4 and Wetumpka.

Velocity observations taken at Lock 4 show a discharge of 3,921 cubic feet, with a velocity of 1.33 feet per second, at a stage of 1.8 feet above low water. Similar observations at Wetumpka, at low water, show a discharge of 5,796 cubic feet, with a velocity of 0.9 feet per second.

In the annual report of the Chief of Engineers for 1879, page 1203, the low-water discharge of the Mississippi River at St. Paul is given as 5,800 cubic feet per second; in the report for 1880, page 482, the low-water discharge of the Hudson River between Troy and Albany is given as about 2,000 cubic feet per second; and in the report for 1881, page 1929, the low-water discharge of the Ohio River at Pittsburgh is given as 1,666 cubic feet at zero of the gauge, and as 5,810 cubic feet per second at 9 inches of the gauge.

Comparing these discharges with that of the Coosa at Wetumpka, it appears that the volume of water flowing in the Coosa at low water is about equal to that in the Mississippi at St. Paul; about 2.8 times greater than that in the Hudson at Albany; and about 3.5 times greater than that in the Ohio at Pittsburgh.

PLAN OF IMPROVEMENT PROPOSED.

In accordance with the terms of the act of Congress, I have to recommend that "the most feasible, economical, and suitable plan" for opening to navigation the part of the river under consideration is to provide a system of slack-water navigation over the greater part of the distance by the construction of dams or dikes to back up the water over the swift shallow portions, and of locks to pass boats from one level to another; and, in addition, to excavate suitable channels through the reefs by blasting out or removing the rock where necessary.

All the reports hitherto made upon the river agree in recommending this system of improvement, and I know of no other having been suggested.

As to the size of the locks and the depth of the channel proper to be provided I quote the following extracts from a report of his inspection of the Coosa River work, submitted to the Chief of Engineers by Lieut. Col. William E. Merrill, Corps of Engineers, on February 11, 1888:

* * * * * * *

The river impressed me very favorably, and it seems as well adapted to locks and dams as the Monongahela, the Kentucky, or the Muskingum.

* * * * * * *

The most serious question is whether or not the present improvement will meet the wants of the people of the Coosa Valley. It is designed to give a low-water navigation for steam-boats of 3 feet. I think that it will undoubtedly secure this object, but whether such a navigation will meet popular expectation is another question.

* * * * * * *

From my long experience with towing coal on the Ohio River, I feel justified in asserting that coal can not be profitably handled on less than 6 feet of water. It is also my opinion that it is hardly worth while to improve the Coosa River by so expensive a process as the construction of locks and dams, unless a navigation is created that will permit the cheap shipment of coal.

On the Coosa these shipments would naturally be made up-stream to Gadsden and Rome, and down-stream to Wetumpka and points below. Locks 1, 2, and 3 belong to the up stream line of navigation, and Lock 4 to the down-stream. As the latter lock has not been begun, I would recommend that it be changed at once to the dimensions already adopted for the Black Warrior River, so as to pass two standard Pittsburgh coal barges (25 by 130) and one tow-boat in one lockage.

* * * * * * *

In accordance with these recommendations, the estimates submitted herewith provide for locks having a clear width of 52 feet, and an available length of 280 feet between the upper end of the lower gate recess, and the chord of the upper miter-sill, with a depth of 6 feet of water on the miter-sills at extreme low water; the locks to be built, throughout, of masonry laid in cement, the inner faces of the side walls, the coping, and the faces of the miter walls to be of cut stone, the rest of rubble.

The locks are designed to be of the most durable construction, of a type similar to those being built by the Government on the Great Kanawha, Monongahela, Muskingum, and Kentucky rivers.

The prices of work and material are based upon recent bids for similar work upon the Great Kanawha River.

The dams are designed to be built of crib-work filled with stone, the abutments to be of masonry where natural rock abutments are not found. As there is no ice to contend with in the Coosa River, the cross-section of the dams need not be made so heavy as is required on Northern rivers.

The dikes are to be built of earth-work paved with stone.

The locations of the locks and dams have been determined from the field maps and profiles, and will be shown on the maps and profiles to be submitted later.

The heights of the dams have been limited to 16 feet, and the lifts of the locks to 15 feet, as the economy of increasing these dimensions is very doubtful, on account of the rapid increase of cost with greater cross-sections of dams and lock-walls.

The desirability of securing good foundations at the least cost for the locks and dams has been kept in view in determining their locations, as well as the necessity of avoiding the overflow of valuable lands in fixing the heights of the dams.

To determine the precise locations of the locks and dams, and the heights of the tops of the lock-walls above the dams, detailed surveys and discharge observations will, of course, be required at each locality selected, but these need not be made until appropriations for the work

become available. No further surveys are needed for the adoption of a general plan of improvement.

To improve the 116½ miles of the river between Lock 4 and Wetumpka, twenty-seven locks, with a total lift of 300 feet, will be required, which, in the tables herewith, are numbered consecutively from No. 5 to No. 31—the last of the series at Wetumpka.

This is an average of one lock to every 4.3 miles of river. In the upper section of 68.73 miles between Lock 4 and the head of Weduska Shoals, there are six locks, with a total lift of 56 feet, or an average of one lock to 11½ miles; and in the lower section of 47.6 miles, there are twenty-one locks, with a total lift of 244 feet, or an average of one lock to 2.3 miles.

The greatest distance between consecutive locks is 25 miles, and the least, .95 mile.

It will be observed by comparison with former projects that the number of locks has been somewhat decreased, by increasing the lifts and heights of dams, whilst the estimates of cost have been very considerably increased. This is due to the large increase of the size of the locks, for the reasons given, from 40 feet width by 210 feet between hollow quoins, to a width of 52 feet by 322 feet between hollow quoins, which is required to give an available length of 280 feet in the lock-chamber, and to the more durable character of masonry provided for. Furthermore, the actual cost of the work already done on the Coosa, as also that of similar work on other rivers, shows that all the former estimates were too low for work of this character.

The estimates submitted for rock excavation provide for a channel 100 feet wide and 4 feet deep, at extreme low water, through such reefs and shoals as are not drowned out by the dams.

In the excavation of this channel work it will very probably be found that some reduction in the cost may be made at certain points by using wing-dams to increase the depth of water over reefs instead of blasting a channel through them.

A depth of 6 feet was not provided for, because extreme low water occurs so seldom and is of so short duration that it was not deemed advisable, for the present, to recommend the much greater expenditure required to procure it. The depth on the miter-sills of the locks at extreme low water having been fixed at 6 feet, should the demands of commerce at any time in the future require a minimum depth of 6 feet in the channels, no change will be necessary in the locks.

ESTIMATED COST.

The following is a summary of the estimated cost of the improvement. The details will be found in Tables II to V:

Four locks, 8-foot lifts, complete, at $163,738	$654,952
Ten locks, 10-foot lifts, complete, at $175,667	1,756,670
Seven locks, 12-foot lifts, complete, at $186,370	1,304,590
One lock, 13-foot lift, complete, at $191,734	191,734
Four locks, 14-foot lifts, complete, at $198,834	795,336
One lock, 15-foot lift, complete, at $204,673	204,673
Total twenty-seven locks	4,907,955
Total dams	489,634
Total dikes	32,955
Total abutments	169,668
Total twenty-seven lock-keepers' dwellings, at $2,500	67,500
Rock excavation in channels between locks, at $2 per cubic yard	407,201
Grand total	6,074,913

The money can be most profitably expended by making appropriations of not less than $1,000,000 in each year.

If the improvement be authorized, it is suggested that authority be given for expending such part of the appropriations as may be necessary in the purchase of needed sites, with the proviso that if the owners of the lands shall refuse to sell them at reasonable prices then the prices to be paid shall be determined and the title and jurisdiction procured in the manner prescribed by the laws of the State of Alabama.

For the 116½ miles of river to be improved the average cost per mile is then $52,145.

An otherwise available route of water transportation from northern Georgia to the Gulf of Mexico, 776 miles in length, is now blocked in its middle portion by a stretch of 116½ miles of impassable river, which can be made navigable at a cost of $6,074,913. Taking this view of the improvement, and distributing the cost over the entire distance, the cost per mile becomes $7,841.

COMMERCIAL BENEFITS OF THE IMPROVEMENTS.

On this subject I make the following extracts from the opinions expressed by my predecessors in reports printed in the Annual Reports of the Chief of Engineers for the years named:

Col. J. H. Simpson, Report of 1871, page 564:

It is fair to assume that the opening of the Coosa River to navigation between Wetumpka and Greensport will be the virtual opening of a channel for direct trade between Rome, Ga., and Mobile, Ala., via the Mobile, Alabama and Coosa rivers, by a water course 700 miles in length, available at all seasons of the year.

The opening and development of the rich and extensive coal and iron mines in the Coosa Valley will render this thoroughfare the great and important feeder of Mobile and the Gulf ports generally. The valuable products of the different counties bordering upon the Coosa River which now seek a market over rough and circuitous roads would naturally tend to this great highway, and the benefits of the great carrying trade thus created would be felt throughout the length of the river. Many products which are now neglected because of the difficulty of transportation would find a ready market and become a source of profit to the producer.

Lieut. Col. Walter McFarland, Report of 1872, page 507:

The region passed through by this portion of the river is very rich in coal and iron, the production of which could not fail to be greatly encouraged by the prosecution of the improvements herein suggested.

Lieut. Col. William R. King, Report of 1877, page 598:

The Coosa River is an exceptionally favorable one for improvement, since its mean depth is greater in comparison with its average width than most of the Western rivers, and its banks and channel are generally well defined and permanent. The necessity for its improvement has been repeatedly urged by legislatures, commercial societies, and engineers.

Maj. A. N. Damrell, Report of 1881, page 1222:

The improvement is believed to be of great local, national, and international importance for the following reasons:

It would give an unbroken water communication of about 800 miles from the Gulf of Mexico to the southern border of Tennessee and northwestern border of Georgia. It would supply a large local demand for fuel, iron, and building materials at rates much below the present. It would reduce immensely to the United States the cost of the large supplies of coal and iron which would be required by it on the Gulf of Mexico in time of war, and in time of peace it would result in a saving in the reduction of the cost of these items to the cities of this section generally, and to the steamers, both merchant and war, of all nations navigating the Gulf, which would soon reach the estimated cost of the work.

Without further lengthening this report, I will only state that I concur fully in the views above expressed.

For statistics and a more extended statement of the advantages to be derived from opening the Coosa River to commerce I respectfully invite attention to the published "Memorial (to Congress) of the Coosa River Improvement Convention, assembled at Montgomery, Ala., March 15, A. D., 1887." The convention was composed of representative citizens of Alabama and Georgia, and was presided over by his excellency, Hon. Thomas Seay, Governor of Alabama. The memorial was prepared by a committee of fifteen members of the convention prominent in the professional and business affairs of the two States.

Very respectfully, your obedient servant,

PHILIP M. PRICE,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. CHARLES FIRTH, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Montgomery, Ala., December 23, 1889.

CAPTAIN: I have the honor to submit the following report of an examination and survey of that portion of the Coosa River in Alabama lying between the site of Lock No. 4 and Wetumpka, Ala.:

The object of the survey was the approximate location of the locks and dams necessary to obtain a system of slackwater navigation between the above points, with an available depth of water of 4 feet, and 6 feet, respectively, during the low-water stage of the river; and also the preparation of an estimate of the total cost of carrying out such improvements.

It was thought desirable, after making every inquiry possible, from men who knew the river at different points, to commence the survey at the upper end, for, owing to the rapid current and the numerous obstructions in the river, it could not be used entirely for transportation purposes, and wagons would have to be resorted to in any case; still there were many portions where the work, of sounding especially, and also the transportation of instruments and articles requiring careful handling, could be very much facilitated by moving down-stream. Again, an instrumental survey had been begun from Wetumpka in 1879, by Gavin B. Yuille, without, however, many levels or soundings being taken, and continued up-stream for a distance of 34 miles; and it was thought that, in the event of the present survey being pressed for time or funds, the transit work and topography could be tied into this, and only new levels and soundings taken from that point down to Wetumpka. This, however, was not taken advantage of, and the present survey was carried right through to Wetumpka without reference to any previous survey or examination.

Therefore, in accordance with your instructions, as soon as the river had reached a sufficiently low stage to render a thorough survey practicable, I proceeded to the site of Lock No. 4 on May 7, 1889, with a properly organized party and outfit, and commenced the work on the following day.

MODE OF PROCEDURE.

Transit work.—The transit line was commenced on the east shore at a point on line with the crest of No. 4 dam, and continued down on the bank of the river, keeping as near the edge of the bank as was practicable, offsets being taken to the edge and to the water-line as often as the formation of the bank required it, and the chainage noted of all fences, gulleys, streams, etc., crossed by the line. Triangulation points were located on the opposite shore at distances varying from 500 to 1,000 feet, and marked by cross-heads and their positions determined from two or more points on the line. So long as both banks of the river were fairly parallel and could be plainly seen only this one line was run; but where the river widened out considerably and the view became obstructed by islands, etc., a line was run down each side and tied in at the ends. This was also done on some of the larger islands where necessary.

Sufficient topography was also included in the transit notes to give the height and slope of banks, bluffs, and ranges of hills, the width of the bottom lands, and the location of tributaries, islands, bars, reefs, villages, mills, etc.

Very soon after commencing it was found that very much better progress could be

made by devoting alternate days to running the line as far ahead as possible, noting chainage and topography on that bank; and triangulating to points on the opposite bank, and taking topography of same. It was also found necessary to cross and recross the river at certain points with the transit line, though not at less distances than about 10 miles, to take advantage of cleared land and to avoid long stretches of dense wood or rocky bluffs.

Wherever the land was cleared and under cultivation a strip of dense wood and undergrowth had invariably been left on the banks to afford protection during floods, etc., and this formed a very considerable, in fact the chief cause of delay in cutting an opening through it, at every few chains, in order to get a sight across to the opposite shore, as even when trees were cut completely through they were held up by vines until everything was cut away. These strips varied in width from 50 feet to as much as 200 or 300 feet.

At the end of the first month's work, finding that sufficient progress was not being made to complete the survey during the present season, a special rod was made and painted, and stadia work was resorted to wherever the banks were fairly parallel and the distance between them not too great. This facilitated matters very much, especially in cutting through the strip of wood along the bank, as advantage could be taken of natural openings better than by the former method. The results proved to be equally as correct as by the former method. All important points, however, were still taken by triangulation.

Levels.—A connected line of levels was also commenced at the same point as the transit work, namely, on line with the crest of No. 4 dam, the datum plane being taken from a bench-mark at that point which showed a height of 495.81 feet, supposed to be above tide water at Mobile, Ala., this elevation being originally taken from the Georgia Pacific Railroad. Levels were first taken along that bank of the river on which the transit line was run, a stake marked with the station having been left at every chain for this purpose. Check levels were always taken back to the starting point each day. On the alternate days the levels were taken on the opposite bank and the location and distances determined by the cross-heads set up at the triangulation and stadia points marked with the figures denoting the chainage on the opposite bank; this work was also checked.

Portable gauge-boards, 8 feet in length, were made and fixed ahead of and behind the party and another kept at each camp. The elevation of the zero of these gauges or mean low-water mark, had to be determined from information received from people living on the river, preferably ferrymen or fishermen, they being the most likely ones to notice the fluctuations. This information, though differing a little occasionally, was accurate enough for all practical purposes.

Elevations of the water surface were taken at the head and the foot of each shoal and at all points between these where a visible change of slope occurred, and also a sufficient number in the pools to determine accurately the water surface, the gauge-readings in each case being deducted from them and allowances made for the variations in width and slope of the surface. Wherever the information could be obtained the level of the highest stage of the water was taken; that of April, 1886, was the highest known, by several feet.

Bench-marks were left at frequent intervals, the position and elevation of each being noted. In the upper reaches of the river where the banks are alluvial, rock could not be found for this purpose, and benches on trees had to be resorted to, only hard, durable woods being used for this purpose; though they can not be said to be permanent, they may be counted on to last twelve to fifteen years.

Soundings.—Soundings were taken in a continuous line down what was judged to be the center of the channel and which was generally pretty well defined, and were taken on those days on which the camp was moved so as to lose as little time as possible. Where the depth was less than 14 feet a rod was used and the soundings were taken about every 100 feet, but where the depth exceeded 14 feet, a lead-line was used, graduated to feet, and distances of 200 feet were considered sufficient.

When sounding, the transit-man and an axe-man went along the transit line and stopped at about every 800 feet, or at less distances if desirable, and noted the stake or hub. When the boat crossed a line at right angles (sighted by the eye) to this point a signal was given by whistle, the sounding recorder replying to show that it was noted, the two books being afterwards compared and the stations marked down. The intermediate soundings were afterwards divided up between these points, but it was found that by watching points on the bank these distances could be gauged very accurately. On the lower portion of the river, where the water was very swift and broken and the banks too rough to travel over even at a walk, the recorder had to locate his soundings from stadia and triangulation points and by natural features, which, however, were frequent enough to determine his position as accurately as by the former method.

The-rear gauge board was taken up on passing and afterwards fixed by the leveler some miles ahead.

It was originally intended to take cross-sections on the shoals, but at the very outset this was found impracticable, considering the time and funds available.

Sufficient information was, however, obtained to locate very closely the position of locks and dams and to prepare an approximate estimate for the same.

Current velocity observations were carefully taken at Wetumpka at the close of the survey when the river was at its lowest stage. The volume of discharge was found to be 5,796 cubic feet per second, with a mean velocity of 0.9 feet per second. Similar observations taken at Lock No. 4, with a rise of 1.8 feet above low water, show a discharge of 3,921 cubic feet per second, with a velocity of 1.33 feet per second.

A permanent gauge was already fixed at Lock No. 4 and read daily, and similar ones were made and fixed at the East Tennessee, Virginia, and Georgia Railroad, being the most convenient point near the middle of the survey, and also at Wetumpka. Arrangements were made to have these read daily at noon and the reports sent in weekly.

The survey was commenced on the 8th May and terminated on 1st November, a period of nearly six months.

It may be stated here that every assistance to bring the work to a successful termination was given by Messrs. H. Archbald, transit-man, Carl Troiel, leveler, A. R. Agee, rodman, and R. L. Bennett, chainman.

PHYSICAL CHARACTERISTICS OF THE RIVER.

The Coosa River, from Lock No. 4, to Wetumpka, Ala., which is the part at present under consideration, is 116.33 miles in length, with a total fall of 322.73 feet. This may be divided into two distinct parts, the characteristic features of each being totally different.

Upper section.—The upper and longer section may be taken as being from Lock No. 4 to the head of Weduska Shoal, a distance of 68.73 miles, with a total fall of 77.76 feet, or a little over 1.1 feet to a mile. In this distance there are several very long pools of various lengths up to 8 miles. The course of the river is winding and the banks are fairly parallel and alluvial; the bed, however, being for the most part of solid rock, with an unbroken surface. The width varies from 500 feet to 1,500 feet, with a depth of water varying from a foot or two on the shoals to over 40 feet in the deepest pools. The rise of the highest known flood over ordinary summer level—that of 1886—varies from 6 feet to 8 feet on the Fort William Shoal to 29 feet at Grissom's Ferry.

With the exception of a few places, bottom lands extend for the whole distance on each side of the river, varying in width from a few feet to considerably over a mile; these are practically all under cultivation.

Several important tributaries come in, which add considerably to the volume of water in the river. The principal of these, in order of rotation, are Choccolocco, Kelly's, Talladega, Tallassee-Hatchee, Upper Yellow Leaf, and Bees-wax Creeks.

There are also a few large islands, most of which are or have been cultivated, the largest being Ogletree's Island in Choccolocco Shoals, having an area of 70 acres, and Bullock's Island in Three Island Shoals, with about the same.

In this upper section the rock is of blue limestone, with good beds, and the best that could be desired for masonry structures.

Lower section.—The lower and shorter portion of the river from the head of Woduska Shoal to Wetumpka, Ala., has a length of 47.60 miles, with a total fall of 244.97 feet, being an average of 5.1 feet to a mile.

Here the river runs a fairly straight course through a rough, mountainous country, most of it well timbered, but with very little cultivation within about 2 miles of the bank on either side, excepting a stretch of about 3 miles beginning at Zimmerman's Ferry, and even there on one bank only. With this exception there are practically no bottom lands.

The banks are exceedingly irregular in outline and are generally steep, rocky bluffs rising direct from the water's edge, often perpendicular, and in one instance, at Carroll's Bluff, attaining a height of from 250 to 300 feet.

These bluffs are much higher, steeper, more regular, and more continuous on the west shore than on the east, and on that side the channel and the deepest water is invariably found, the water always having a tendency to draw towards that side, in low-water stages often running to it at right angles to the natural course of the river; where this feature is very marked, and it occurs very frequently, the channel usually has a clear water-way of from 200 to 400 feet, with a very rapid current, while the other or eastern side of the river, with sometimes a width of 2,000 feet, is an intricate mass of bare rugged rocks in the form of reefs, or more or less isolated rocks with shallow rapid water between them. Somewhere about thirty years ago the channel was roughly cleared of loose rocks and used as a boat chute by flat-boats carrying cotton to Mobile during the flood stages of the river. The flats of course could not be brought back.

The profile of this lower section of the river shows a succession of short deep pools, except at Zimmerman's Ferry, seldom more than 1 mile in length and connected by wide shoals of various lengths up to 12½ miles, consisting of numerous reefs, isolated rocks and islands of all sizes, with swift broken water running all through amongst them and over low ledges in perpendicular falls; in all of these shoals, however, there is at least one channel where the water is of considerable depth, though necessarily very rapid and broken and sometimes obstructed by isolated rocks.

One of the chief characteristics of this section of the river is the irregularity of the profile of the rocky bed, even in the pools, where sometimes a depth of 80 feet would be immediately followed by one of 4 feet or 5 feet in a horizontal distance of 100 feet. The bed is invariably solid rock, with a total absence of sand or gravel bars.

The width of this section of the river varies from 390 feet, at "The Narrows," with a depth of over 85 feet, to 3,700 feet in "Butting Ram Shoals," with a depth of 2 or 3 feet; the greatest rise in the river during the highest floods being 5 feet over low water at the latter point, while at Wetumpka, Ala., it attained a height of 53 feet, this, of course, being governed by the width and slope.

The islands in the lower section of the river, though more numerous than in the upper section, are not as large, and only a few are, or have been, cultivated. Creeks and streams—locally called branches—may also be classed in the same way, viz, much more numerous but of less volume.

It may be added that for the last 5 miles above Wetumpka the banks undergo another decided change, though still retaining their high precipitous faces; they are in that distance formed of alluvial soil instead of rock, while the surface of the land above is almost a dead level and for the most part under cultivation. This feature is again more distinct on the west side than on the east.

There is, in the whole of the lower section, an abundance of stone suitable for cribs, riprap, and rubble-work, which can be obtained at very small cost for quarrying and little or no transportation. At many points a good compact gneiss was found suitable for masonry, though, of course, not so easily worked as the limestone on the river above.

PLAN OF IMPROVEMENT.

The plan of improvement proposed is the establishment of a system of slackwater navigation, giving a depth of 4 feet over the various reefs and shoals obstructing the river by the construction of a series of locks and dams with short reaches of canal along the river side, where advantage can be taken of islands and reefs for their formation; in such cases avoiding the construction of long high dams across the river that would prevent the passage of boats over them except during the highest floods, and also effect the least possible change in the overflow of bottom lands during floods.

The locks to have a depth of 6 feet on the miter-sills at mean low-water stage, or 2 feet deeper than the normal depths of the pools between them. As these points, however, would be comparatively few, it would be an easy matter to increase the depth on them to the same as on the miter-sills without any interference to navigation should such be deemed necessary at any future time.

When the channel through the natural pools at deep-water reaches is obstructed by reefs or by isolated rocks, blasting will have to be resorted to to give a sufficient channel way, which it is proposed to make 100 feet wide with a minimum depth of 4 feet at low water.

OBSTRUCTIONS TO NAVIGATION AND IMPROVEMENTS SUGGESTED.

Lock No. 4 to Georgia Pacific bridge.—From the site of Lock No. 4 to the Georgia Pacific Railroad bridge, a distance of 3.6 miles, there are few obstructions to navigation; these consist of a few points of rock, in most cases isolated; in one place only it takes the form of a reef, just above the bridge. This, however, could be avoided entirely by keeping along the west shore. About 6,356 cubic yards of channel work in all would be required. With these exceptions there is ample depth and smooth water, having a fairly uniform width of 700 feet.

The Georgia Pacific Railroad crosses the river on a new iron through-truss bridge of four spans, with masonry abutments and piers. The clear height from low-water level to the under side of the crossbeams is 27.46 feet. High-water level in 1886 was within 2 feet of these beams. No provision has been made for a draw-span, which will be required.

Georgia Pacific bridge to Robertson's Shoal.—From here to the head of Robertson's Shoal, a distance of 4 miles, there are no obstructions; the river is smooth, the width averages 600 feet, and the depth is considerable, up to 42 feet, opposite the mouth of Blue Eye Creek, which flows in from the east about 1¼ miles below the bridge.

At Robertson's Shoal the width of the river is 1,200 feet, in the center of which lies Robertson's Island, cultivated, 2,200 feet in length, with a greatest width of 350 feet. It lies somewhat nearer the east bank and is connected with the same by a gravel bar, on which there are only a few inches of water. The channel is on the west side and is at present obstructed by four reefs, apparently of loose rock. About 8,773 cubic yards of channel work would be required. A few isolated rocks are found above these reefs, but there is plenty of water alongside of them.

Truss's Ferry to Choccolocco Shoal.—Truss's Ferry is situated at the lower end of the island, the river at that point being 900 feet wide. This is the crossing point between Ashville and Talladega, the county towns of St. Clair and Talladega counties.

Three-quarters of a mile below Truss's Ferry are the remains of an old fish-trap dam, extending right across the river; this, however, is all of loose stone, but about 3,500 cubic yards of channel work would be necessary, through the reef on which it is built.

About 2½ miles below Truss's Ferry is the head of the Choccolocco Shoals. Here the river attains a greatest width of 2,400 feet, and at the lower end makes a sharp bend to the west. On the east side of the river, practically forming the east bank, lies Ogletree's Island. This is cultivated and contains about 70 acres. Behind the island Choccolocco Creek comes in from the eastward. This creek is 150 feet wide at its mouth, with a depth of 10 feet, and is the most important tributary to the Coosa River. At the end of the island, Howell's Branch comes in, also from the east. Immediately below Ogletree's Island, and almost joined with it, is Sheep Island, having an area of about 15 acres, partly cultivated, and between this and the east bank is a small island known as Buzzard Island.

The shoal proper lies between the islands and the west bank of the river; the bottom is very regular and uniformly shallow throughout, with a depth of about 2 feet, apparently rock, overlaid with gravel. Two small rocks are the only ones visible on the whole shoal. The length is about 2 miles, and the amount of fall in the water surface at the lower end too considerable for channel work.

The improvements suggested here consist of a lock and dam with a lift of 8 feet situated about the middle of Sheep Island; it would be inadvisable to make this lift higher on account of the low nature of the banks on each side; it would also be necessary to connect the islands by a dike and to build a dam from the head of Ogletree's Island to the east shore: this plan would allow the flood waters from Choccolocco Creek and Howell's Branch to get away without hindrance from the main dam. About 1,480 cubic yards of channel work would be required.

Choccolocco Shoals to the Talladega and Coosa Valley Railroad Bridge.—From the lower end of Choccolocco Shoals for a further distance of 2 miles the river has an average width of 1,000 feet, with a few small islands near the shores. The water, though smooth, is very irregular in depth, and 18,578 cubic yards of channel work would be required. A series of cross-sections would, however, be taken before this would be done, and would perhaps show a good channel with much less work, if not quite so straight.

From here to the bridge of the Talladega and Coosa Valley Railroad, a distance of about 1 mile, there is deep eddy water, with a uniform width of 600 feet; just above the bridge is Collins's Ferry.

The Talladega and Coosa Valley Railroad crosses the river on a composite, through-truss bridge of four spans, narrow gauge, wooden trestle approaches, and cast-iron column piers on crib foundations; the clear height above low water to the underside of the cross-beams is 30 feet. No provision has been made for a draw-span. This road is now being changed to standard gauge, which will probably necessitate a new bridge being built.

Talladega and Coosa Valley Railroad Bridge to Howell's Mill.—From here to within one-quarter of a mile of the head of Curry's Island, a distance of 1¼ miles, is deep eddy water, with a uniform width of 600 feet.

Curry's Island is cultivated and has a length of 2,400 feet and a width of 400 feet at its widest part, the river here being 1,400 feet wide; the channel is on the west side and is of ample depth, except at the head, where a reef of rock, on which are the remains of an old fish-dam, extends right across the river. About 10,920 cubic yards of channel work would be required. A short distance above the island a high rocky range of hills strikes the river on the east bank and at once recedes again; at this point the course of the river takes a very sharp bend to the west.

From Curry's Island for a distance of 2½ miles is locally known as Collins' Bend, the width of the river averages 1,000 feet for the greater part of the distance, and the water is of ample depth, with the exception of a few reefs, where about 4,680 cubic yards of channel work would be required.

Here the Drake's Mill Shoals commence, with Griffith's Ferry near the head; the river widens out to 2,000 feet, with a large island partly cultivated near the east bank, and is very much broken up by reefs, small islands, and isolated rocks. The old mill which formerly stood on the west bank is gone, but the dam still remains. There are

numerous fish-traps scattered about the river over its whole width. Shallow water, averaging 3 feet in depth, extends for about a mile below the mill, where round a sharp bend to the west a stretch of deeper water 1 mile long begins and continues to within half a mile of Howell's Mill, where the Howell's Mill Shoals begin, extending to within a short distance of Upper Clear Creek, which comes in from the east half a mile below the mill. This shoal is in many respects similar to that at Drake's Mill. A large island lies near to the east bank, and is connected to the same from its lower end by the mill-dam; the mill is in operation. The remainder of the river is broken up by rocks, reefs, and fish-traps.

The improvements suggested consist of a lock and dam of 10 feet lift, situated about 400 feet above the mouth of Upper Clear Creek. This would back the water over both Howell's and Drake's Mill Shoals almost up to Griffith's Ferry before mentioned, leaving only 13,490 cubic yards of channel work through the latter shoal.

Howell's Mill to Bell's Island.—From Upper Clear Creek to Bell's Island, a distance of 3½ miles, the river maintains a width of about 900 feet, but, with the exception of a very few places, is exceedingly shallow throughout, with a very uniform surface of bed. In this distance, at about 1 mile from Upper Clear Creek, is Vincent's Island, of about 10 acres, under cultivation; the deepest water lies between this and the west bank. Grissom's Ferry is situated at the lower end of the island.

The improvements suggested consist of a lock and dam, with a lift of 10 feet, situated at the head of Bell's Island. This would back the water up to the foot of the previous lock, and no channel work whatever would be required.

Bell's Island to Lower Clear Creek.—Bell's Island, uncultivated, lies near the west bank, and evidently, at no very remote period, formed part of that bank of the river. Between it and the east bank the water is shallow and rapid, and the channel is obstructed by a double fish-trap near the lower end.

From there to Kelly's Creek on the west side is a distance of 1½ miles, the width is about 700 feet, and the depth of water about 6 feet, except at one point.

Kelly's Creek is an important tributary to the river, and is 125 feet wide at the mouth with high banks, and a depth of water of 11 feet.

Two hundred yards below the mouth of Kelly's Creek is the head of Ratcliffe's Shoal, extending round a large cultivated island of the same name to the foot of it, altogether a distance of somewhat less than 1 mile. The channel is between the island and the west shore and is extremely shallow.

Half a mile below the island is Glover's Ferry, and at the west landing of which Spring Creek comes in. From Glover's Ferry the river flows round a long easy curve to the east and has an average depth of about 10 feet till the head of Hall's Island is reached, nearly 2 miles below, at the head of which is a reef running right across the river with very little water on it. Hall's Island is uncultivated and lies about the middle of the river, the channel being on the west side. From here down to Lower Clear Creek, which comes in on the east side, is a further distance of 1¾ miles; the banks are parallel, about 700 feet apart, but the water for the last mile is very shallow. A well-defined reef of rock extends across the river at a point about 500 feet above the creek, below which the water suddenly deepens.

The improvements suggested here consist of a lock and dam with a lift of 12 feet situated on the reef before mentioned, which would back the water up over all the reefs and shoals to the foot of the previous lock at the head of Bell's Island. No channel work would be required.

Lower Clear Creek to the Savannah and Western Railroad Bridge.—At Lower Clear Creek the river narrows to about 600 feet, with high level banks on each side, and turning sharply to the west becomes somewhat tortuous, but in regular curves. One thousand feet below the creek is Meyer's Ferry; it is at this point that the rock first begins to crop out of the banks, but only to a slight extent. The width continues uniform at 600 feet, and the depth 10 to 20 feet, with a few exceptions, the first of which is about 1½ miles below the creek where about 920 cubic yards of channel work would be required.

Four and a half miles below Lower Clear Creek, Talladega Creek, of considerable volume and some importance, comes in from the east, 1 mile below which on the same side is Tallassee-Hatchee Creek, also of considerable size. Just above the mouth of the latter a reef of rock runs diagonally across and up the river, which here turns sharply to the west; the current over the reef is slight. About 1,980 cubic yards of channel work would be required.

Half a mile below Tallasseee-Hatchee Creek, the Savannah and Western Railroad crosses the river on a new, iron, through-truss bridge of four spans, the eastern abutment is of masonry, the western an ordinary pier with wooden-trestle approach; the piers are of masonry. The clear height from low-water level to the underside of the cross-beams is 42.4 feet. The high water in 1886 rose about 25 feet at this point, which would leave 17.4 feet headway. No provision has been made for a draw-span.

Savannah and Western Railroad Bridge to the East Tennessee, Virginia and Georgia Railroad Bridge.—From the bridge to the head of Prince's Island, one-quarter of a mile,

the river is deep. Prince's Island is long and narrow, lying about the middle of the river, the channel being on the east side, which at the upper end is very shallow. About 5,360 cubic yards of channel work will be required. Chancellor's Ferry is situated at the lower end of the island.

From here, for three-fourths of a mile, the river is wide and deep up to the head of an island, 2,000 feet long lying near the west bank, the channel being on the east side and very shallow for its entire length, requiring 22,220 cubic yards of channel work, and becoming deep immediately after passing the lower end of the island, maintaining a depth of 10 to 40 feet from there to the bridge of the East Tennessee, Virginia and Georgia Railroad, a distance of nearly 5 miles, round what is the sharpest bend of the river, doubling to the east, directly back on its own course, then turning off to the west.

The East Tennessee, Virginia and Georgia Railroad bridge is the oldest one on the river, having been built about thirty-five years, and is mentioned in old reports on the Coosa River as the Selma, Rome and Dalton Bridge. It is a wooden, Howe, through-truss of five spans, with masonry abutments and piers. The clear height from low water to the underside of the cross-beams is 31.17 feet. The flood of 1886 rose within 7 feet of them. There is no provision for a draw-span.

East Tennessee, Virginia and Georgia Railroad Bridge to Fort William Shoals.—Four hundred feet below the bridge Kahatchee Creek comes in on the east side. From the bridge, the river turning sharply to the west, then again to the east, maintains a depth of 20 to 40 feet to the head of Three Island Shoals, a distance of 3 miles; 1½ miles below the bridge Upper Yellow Leaf Creek comes in from the west; this is a large and important tributary; three-quarters of a mile below the creek is Oden's Ferry.

At the head of Three Island Shoals the river widens out to 1,500 feet, and at the head of Bullock's Island, the widest part of the shoal, it attains a width of 2,000 feet. The river is here divided into three channels by two large parallel islands, the deepest water being found nearest the west bank.

Bullock's Island, the larger of the two, is 1¼ miles long, having at the upper end a greatest width of 700 feet, and at and above this upper end is the shoal proper. On the west bank, opposite the head of the island, are the remains of an old mill, and one of the chief obstructions in the river is the old dam. This would require removal and about 38,700 cubic yards of channel work done. The latter, however, could probably be materially lessened by the construction of a wing-dam, which would throw a large proportion of the water over on to the west shore. Between the lower part of Bullock's Island and the west shore there is a sufficient depth of water, though variable; but at the foot is a narrow reef, requiring 2,213 cubic yards of channel work.

Hays' Spring Branch comes in here from the east, and the river turns to the west. Immediately below the bend is another and larger reef, requiring 1,660 cubic yards of channel work.

Thence to the head of Fort William Shoals, a distance of 5 miles, there is deep water, over 40 feet being found at McRae's Ferry, 2½ miles below Bullock's Island. Half a mile below McRae's Ferry the Pope Branch comes in from the east, opposite to Booly's Creek on the west. One and a quarter miles below the ferry Beeswax Creek comes in from the west, and is an important tributary. One half mile lower down is the Sally Branch on the same side.

One and a half miles below Beeswax Creek is Steam-boat Island, formerly much larger, but now rapidly wearing away through the action of the water, till at the present day it has a length of 1,000 feet with a width of 12 to 15 feet. Mud Creek comes in behind it from the east. At the head of Fort William Shoals Flat Branch comes in from the west.

At Fort William Shoals the river gradually widens out to 1,900 feet at the widest part, narrowing again just below the Kelly Branch on the west side to 1,200 feet. The whole expanse is very shallow, with broken water running over a succession of well-defined reefs extending from shore to shore, isolated rocks being rare.

The improvement suggested consists of a lock and dam with a lift of 8 feet, the lock to be situated on the west bank between a small island and the mainland; this would afford a certain amount of protection from drift, and would be better protected during floods. This height would back the water up onto the reef before mentioned below the foot of Bullock's Island, where the amount of channel work was calculated with this in view.

Fort William Shoals to Peckerwood Shoals.—Fort William Shoals still continue for a mile lower down to where Cedar Creek comes in from the east opposite the head of an island, at the lower end of which is Fort William Ferry, which now takes the place of an old ford, situated 1,000 feet above Cedar Creek.

From the ferry there is good water, with the exception of one well-defined, narrow reef, down to the mouth of Sulphur Spring Branch on the east side, a distance of three-quarters of a mile, where it suddenly shoals and remains so down to Peckerwood

Bar, a further distance of three-quarters of a mile, the width for the whole being fairly uniform at 1,100 feet.

Peckerwood Bar is a well-defined reef of rocks running from Peckerwood Island, situated near the west bank, diagonally down the river to the east bank, and showing above the surface at intervals all the way across.

The improvement suggested consists of a dam built on this shoal and a lock with a lift of 8 feet situated between the island and the west bank, where the same protection would be afforded as at the previous site. This would back the water up to the foot of the previous lock and no channel work would be required.

Peckerwood Shoal to Weduska Shoal.—Peckerwood Creek comes in from the east a short distance below the bar. From here to the head of Weduska Shoal, a distance of over 5½ miles, there is a depth of water of 20 to 50 feet, with a winding course.

In this distance, Merrill's Ferry is 1½ miles from Peckerwood Creek; a settlement ferry 2 miles lower down, with McGuire's Spring Branch just below that on the west side, and Wood's Ferry a farther distance of 1 mile.

This concludes the description of the upper section of the river.

Weduska Shoal.—The Weduska Shoal consists of a wide basin, surrounded on all sides by high steep hills and precipitous bluffs; it has a total length of 1 mile and a greatest width of 3,200 feet; several small islands are situated near the head. The river enters it with a perfectly smooth, calm surface, having a width of 660 feet and a depth of 30 feet, and immediately spreads out into a wide sheet of broken water, tumbling over rocks and reefs and obstructed towards the lower end by willows and long reeds; near the foot the surrounding hills close in rapidly, and the river leaves the basin through a rocky gate-way called "The Narrows," 390 feet in width at its narrowest point, with a depth of water of over 85 feet, having a perfectly smooth surface; a considerable eddy runs upwards along the west shore. The deepest water throughout the shoal is alongside of the east bank, though here is also the steepest slope of the water surface.

The improvement suggested consists of a lock of 10 feet lift at the foot of the shoal water where the basin first begins to narrow and a longitudinal dike parallel with the east shore built on a reef of rocks inclosing the present channel or chute and connected with a rocky island at the head. This would back the water up to the level of the smooth water at the head of the basin, and would at the same time allow flood water to retain a perfectly unobstructed channel through the remainder of the shoal.

The Narrows to the Devil's Race.—After passing the Narrows the river immediately widens out to 2,400 feet, as though it ran into a lake, the east side of which is filled with islands of various sizes; reeds, willows, and tow-heads amongst the former. Baker's Island was formerly cultivated. The channel or chute turns sharply to the right on entering this wide space and follows the west shore, running along the foot of a steep rocky cliff, which extends from here almost all the way to Wetumpka.

From the Narrows to the mouth of Waxahatchee Creek, a large tributary during flood time, coming in through the hills on the west, is a distance of 1½ miles; the water is alternately very deep and very shallow; points of rock reaching almost to the surface are surrounded by deep water.

At the mouth of Waxahatchee Creek is a short rapid, over which the water has a considerable fall, and is very much broken by rocks and small islands.

The improvement suggested here consists of a lock and dam of 10 feet lift which would back the water over this shoal and over all the shallow places as far back as the Narrows, leaving only about 790 cubic yards of channel work through a reef near the head of the pool.

About 1¼ miles below Waxahatchee Creek the river has a moderate current, with sufficient water, very deep in places, to the head of the Devil's Race, situated between the west bank and a mass of islands near it, with swift water running through them in all directions. This condition continues down the river for a distance of 1¾ miles, where it finally ends in a reef extending from bank to bank, having a fall over it of about 3 feet. The current throughout the entire distance is very swift, so much so as to render it impossible to get soundings in passing through. The river outside of the race is a mass of islands, tow-heads, and reefs.

The improvements suggested here consist of two locks and dams, the lower one with a 12-foot lift, to be situated on the reef before mentioned, which would back the water up for a distance of 1 mile, where another lock and dam, also of 12 feet lift, would be required, which would in its turn back the water up to the foot of the lock at Waxahatchee Creek.

Devil's Race to Butting Ram Shoals.—A short distance below the foot of the Devil's Race, Paint Creek comes in from the east, with an upper and lower mouth, forming between them Bates's Island, partly cultivated. The river here turns to the west, and is obstructed on the east side by numerous islands of all sizes, Morgan's and Gentry Islands, both cultivated, being the largest. To Adam's Ferry, a distance of 2½ miles,

is a succession of pools and reefs. Lower Yellow Leaf Creek is an important tributary, coming in from the west a few hundred feet above the ferry.

The improvements suggested consist of a lock and dam of 10 feet lift, situated on a reef about 1,500 feet above Lower Yellow Leaf Creek, which would back the water up to the foot of the previous lock. No channel work would be required.

At Adam's Ferry the river suddenly contracts to a width of 600 feet with a depth of 50 feet, but widens out again immediately below, with Johnson's Island in the middle. This is a large cultivated island, 4,400 feet long by 1,000 feet wide, standing high out of the water. The channel is on the west side, with plenty of water, except at the foot, where a succession of reefs begin. The river here contracts to 1,200 feet, immediately afterwards widening out into the Butting Ram Shoals, where it attains its greatest width of 3,700 feet.

The Butting Ram Shoals have a length of nearly 2½ miles, and may be said to be divided into two parts longitudinally by Pate's and Sauley Islands, situated on line with each other and separated only by a narrow slough; the islands are for the most part cultivated and stand high out of the water. On the west side of them the river is a mass of small islands, reefs, rocks, and broken water, the largest, called Rock Island, being 1,200 feet long by 400 feet wide and 250 to 350 feet high; an enormous mass of bare rugged rock, almost perpendicular at the upper end and sides. Between this and Sauley Island is the rock known as the Butting Ram, similar to it, but much smaller. On the east side of the dividing island is a well-defined series of pools and reefs.

The improvements suggested consist in using this latter channel as a natural canal, by building longitudinal dikes on the lowest portions of the islands and obtaining the necessary depth of water over the reefs by means of two locks and dams, the lower one to have a lift of 15 feet, situated at the foot of Sauley Island, where only a short dam would be necessary; this would back the water up to a point about 1,700 feet above the slough, dividing the two islands, which would be joined by a dike. Here a second lock and dam, with a lift of 14 feet, would back the water up to the foot of the lock above Adam's Ferry. It would also be necessary to build a dam across the west channel, near the head of the upper island, for which purpose a suitable reef exists. About 6,920 cubic yards of channel work would be required.

Butting Ram Shoals to Zimmerman's Ferry.—From the foot of Butting Ram Shoals the river is wide, averaging 1,400 feet, and very shallow, to the foot of Tuck-a-league Shoal, a distance of 2½ miles. The latter shoal has a considerable fall and is much broken up by numerous small islands and tow-heads. On the west side is a somewhat dangerous whirlpool locally known as "The Suck."

The improvements suggested consist of two locks and dams; the lower one, having a lift of 12 feet, situated about 2,000 feet above the foot of the shoal, would back the water up for about 1 mile, where another lock and dam with a lift of 13 feet would be required to back the water to the foot of the lock at Sauley Island. No channel work would be necessary, and "The Suck" would be drowned out.

At the foot of Tuck-a-league Shoal are three small islands lying near the west bank, and half a mile below there is the head of House's Island, where Walnut Creek comes in from the west. House's Island is cultivated and has a length of 1 mile with a width of 900 feet; the channel is on the east side, but is shallow and obstructed by rocks and fish-traps.

The improvements suggested consist of a lock and dam, with a lift of 10 feet, situated at the foot of the island, which would back the water up to the foot of the previous lock.

Zimmerman's Ferry to Duncan's Riffle.—Just below the foot of House's Island is Zimmerman's Ferry, and from here to the head of Duncan's Riffle, a distance of over 5 miles, is a clear stretch of water about 700 feet in width and of ample depth, except at one or two places near the ferry, where about 2,500 cubic yards of channel-work would be required. The banks of this part of the river are regular and the general appearance is more like that above Weduska Shoal. There is also more land under cultivation here than on any other part of the lower section of the river.

One mile below Zimmerman's Ferry, Hatchet Creek comes in from the east; this is an important tributary; 1¾ miles further down is Smith's Ferry, by the west landing of which Cargal's Creek comes in.

At Duncan's Riffle the river, after turning to the east, doubles back on itself to the west round the foot of a high range of hills and immediately becomes broken up among ledges of rock, small falls, and reefs; then turning to the east again and continuing on its former course. This, though short, is one of the worst places on the river.

The improvements suggested consist of a lock and dam, with a lift of 10 feet, situated at the foot of the broken water, which would back the water up to the foot of the lock at House's Island.

Duncan's Riffle to Hell's Gap.—About half a mile below Duncan's Riffle the river-bed contracts to a width of 500 feet, and on each side a ledge of rocks juts out, still fur-

ther contracting the water-way to a width of about 200 feet, where there is a depth of over 75 feet. After passing this it widens out again to 600 feet, and maintains a very considerable depth to the head of Fish Trap Shoals, a little more than 2 miles from the Riffle.

In this stretch about 1½ miles down is Knight's Ferry, situated just below Carroll's Bluff on the west side. Carroll's Bluff is from 250 to 300 feet high.

At a bluff called Twenty-four Mile Point, just below Knight's Ferry, the river widens out to about 2,000 feet and the Fish-Trap Shoals commence. This is a wide shallow stretch of river over 2 miles in length, ending at Hell's Gap. The deepest water is on the west side, with a very swift current; the remainder of the river, for three-quarters of its width, is obstructed by rocks, reefs, small islands, and tow-heads. At the lower end is Hell's Gap, which consists of a chute through a reef, down which the water comes with considerable force.

In this distance Chestnut Creek, a large tributary, comes in on the west side, somewhat less than 1½ miles below Knight's Ferry, and Proctor's Creek one-half mile further down on the east side.

The improvements suggested here consist of a lock and dam, with a lift of 12 feet, situated just below the gap. This would back the water up to the pool at Knight's Ferry, and only about 5,910 cubic yards of channel-work would be necessary.

Hell's Gap to Staircase Falls.—About a mile below Hell's Gap is Pinchoulee Creek, on the east side, throughout which distance is a channel of smooth deep water next to the west bank. One thousand feet below here a well defined reef extends diagonally across the river, with very little water on it, and after about 1,500 feet of deep smooth water is another and similar reef; then a deep pool, a little more than one-half mile in length, about the center of which was Thompson's Ferry, now disused, where the river contracts to 400 feet, but immediately widens out again on the next shoal to 800 feet.

The improvements suggested consist of a lock and dam of 14 feet lift, situated at the foot of the last shoal, which would back the water up to the foot of the lock at Hell's Gap.

Below this, for a distance of 1 mile, there is good water, the river again contracts at one point to 400 feet in width, and has a depth of 30 feet throughout; then for a further distance of 1 mile come a succession of reefs and swift water; opposite Welonee Creek, which comes in from the east, the whole width of the river is obstructed by rocks. Except on the crests of the reefs there is generally sufficiently deep water, up to 20 feet, amongst them. A long wooded island lies next the east shore at the foot of this shoal.

The improvements suggested consist of a lock and dam, with a lift of 10 feet, situated at the foot of the island, which would back the water over all the reefs to the pool beyond. No channel work would be necessary.

Then for a distance of over 3 miles is a stretch of very deep pools of water, with a rather tortuous channel, separated by two or three narrow reefs; the water, however, though unbroken except over the reefs, has too swift a current for a steam-boat to make headway against the fall, being about 5.5 feet per mile, and it will therefore be necessary to check this.

At the upper end of this reach Town Creek comes in from the east, and half a mile below it is Grey's Ferry.

The improvements suggested consist of a lock and dam, with a lift of 10 feet, situated just above the mouth of Shoal Creek, which here comes in from the west. The river here is very wide and shallow, and the dam, though a long one, will be low and easily built.

From Shoal Creek to Staircase Falls the river is very wide—averaging 2,000 feet—and shallow, with a considerable fall in the water surface. The whole area is a mass of reefs, rocks, and tow-heads. The channel, especially at the falls, is exceedingly tortuous and full of rapids and falls. Finally, after passing the lowest and heaviest rapid, it turns almost at right angles between large masses of rock. In the angle of the river on the east side is Buyck's Island, rocky and uncultivated, behind which Wewoka Creek comes in from the east.

The improvements suggested here consist of a lock and dam, with a lift of 12 feet, situated on a ledge of rocks jutting out from the west shore below the falls; the dam, on account of the formation of the reefs, would have to cross the river from the head of a small island about 500 feet above the lock, to which it would be connected by a longitudinal dike.

Staircase Falls to the Big Eddy.—From Staircase Falls to the head of Gunn's Island, a distance of 2¾ miles, the river is alternately deep and shallow, a succession of holes and reefs, with a very steep slope; the channel here is the most tortuous and irregular on the whole river, and the whole distance is obstructed by rocks and reefs. Closet Reef is a formidable one at the lower end.

The improvements suggested consist of a lock and dam, with a lift of 14 feet, situ-

ated on the east shore just above Gunn's Island; this would back the water up over all the obstructions. No channel work would be necessary.

Gunn's Island is 2,400 feet long by 300 feet wide, and is partly cultivated; the water is very shallow on each side of it; 500 feet below the lower end Sofkahatchee Creek comes in from the east. For a distance of three-quarters of a mile below it the river, though much less obstructed by isolated rocks, is very shallow, the average width being about 1,000 feet, and at the lower end the channel is tortuous.

The improvements suggested consist of a lock and dam, with a lift of 12 feet, located on a convenient reef of rock on the west shore, at the foot of this shallow water; this would back the water up to the foot of lock above, and no channel work would be required.

Big Eddy to Moccasin Reef.—A reach of deep water, known as the Big Eddy, begins at this point and continues down the river for about 1½ miles, with a fairly uniform width of 600 feet. At the upper end on the east bank is Buzzard Rock, an almost perpendicular cliff of bare rock, rising directly out of the water. At the foot of the Big Eddy the river widens out to about 1,500 feet, and is an intricate mass of islands and rock, forming what is known as Grey's Island Shoals; the channel lies between a chain of islands and the west bank, but is shallow and has a very swift current, with rapids at intervals. The total distance from the head of the shoal to the foot is a little over 1 mile. Rose's Creek comes in from the east, near the foot.

The improvement suggested consists of a lock and short dam, with a lift of 8 feet, situated at the foot of the chute between the islands and the west bank, and a longitudinal dike connecting the islands which form the chain; this would back the water up to the level of the Big Eddy and no channel work would be necessary, nor would any dam across the river at any point be required, thus leaving an unobstructed passage for flood water.

Moccasin Reef to Wetumpka.—From the foot of this shoal there is another reach of deep water about 1 mile in length to the Moccasin Reef, a jagged, well-defined ridge of rocks which extend from shore to shore, having a fall of 3½ feet over them. Below this the river is smooth, having a very uniform depth of 6 feet to the head of Corn Creek Shoals, about one-half mile below.

The Corn Creek Shoals consist of three distinct reefs with about three-fourths mile of smooth deep water between them. Corn Creek comes from the east at the foot of the lowest fall.

The improvements suggested consist of a lock and dam of 10 feet lift, situated at the lowest fall; this would back the water over all the Corn Creek reefs, and over the Moccasin Reef above, into the pool beyond. No channel work would be necessary.

From the foot of Corn Creek Shoal to the head of the Wetumpka Falls, a distance of 1½ miles, is a pool of smooth deep water, unobstructed except near Wetumpka, where ridges of rock run out diagonally from the east bank, and with the exception of the channel fill up the whole of the river-bed to the foot of the rapids. The rapids are over one-half mile in length, the slope is steep, and the channel is irregular, making a right-angled turn at the head.

A new, iron, through-truss wagon-bridge of five spans on cast-iron columns and brick abutments crosses the river near the foot of the rapids; the height from low-water level to the under side of the cross-beams is 57.46 feet; the high-water level of 1886, however, reached a point 6 inches higher than the beams. No provision has been made for a draw-span.

The improvements suggested consist of a lock and dam of 14 feet lift; the lock to be located on the east bank at the lowest point of the reefs; which point is the head of the present navigation. The most convenient location for the dam would be about 1,200 feet above the lock, a short distance above the bridge, as the height required would be less at that point, the width of channel at low-water stage, and the depth is less also; this would necessitate a longitudinal dike of 1,200 feet, connecting the dam with the lock.

This would be the last lock of the series.

CONCLUDING REMARKS.

From the above description and suggested improvements, it will be seen that a total of twenty-seven locks and dams is considered necessary, with the following lifts: Four, with lifts of 8 feet; ten, with lifts of 10 feet; seven, with lifts of 12 feet; one, with lift of 13 feet; four, with lift of 14 feet; one, with lift of 15 feet. Total number twenty-seven, with total lifts of 300 feet. It will also be seen that what has been termed the upper section of the river, having a length of 68.73 miles, only requires six locks, with a total lift of 56 feet, whereas the lower section, with a length of only 47.60 miles, requires twenty-one locks, with a total lift of 244 feet.

The locks are located by the aid of the plans and profile, and from information obtained and soundings taken during the survey, particular care being taken in each

case to prevent the possible flooding of adjacent lands to any greater extent than annually occurs at the present time.

Before construction could be commenced at each individual site a detailed survey, having special regard to the contour of the reefs, etc., would be necessary to make the exact location in each case; velocity observations during rising floods would also be required to find the discharge and determine the height of the guard-walls; but taking into account the very important differences in level between high and low water stages, in very few cases would it be sufficiently high to prevent their submergence during the highest stages; they would therefore be designed to admit of the passage of boats through the locks until such time as it was possible and safe for them to pass over the crest of the dam. More than this it would be useless to provide for, as the nature of the river on the lower section would preclude the passage of boats either up or down the river during higher stages.

The size of the proposed locks has been fixed at a length of 322 feet between heel-post centers, by a clear width of 52 feet, both in gateways and chamber; thus giving an available length of 280 feet in the chamber. These dimensions admit of the passage of the largest tows likely to be used on the improved river, which would consist of a tow-boat 150 feet long and three barges each 130 feet long.

The dams to be of the fixed type and to consist of crib-work and stone.

The numbers used to designate the locks on the plans and tables commence at the upper end, the first one being No. 5, and are numbered consecutively down to that at Wetumpka, which is No. 31. This is done to prevent confusion with the numbers of the locks on the river above that part now under consideration, and to make the numbers continuous throughout the entire system.

With regard to the channel work, the quantities given are those which would require removal without any attempt at lessening them by the aid of wing-dams, but there is no doubt that there are many places where such could be used to advantage, and by their means a greater depth of water directed across certain points, where excavation would otherwise be necessary.

If at any time a further depth of 2 feet was required, thereby giving a depth of 6 feet at low water, an additional amount of 463,220 cubic yards of channel work would be required.

A table of distances accompanies this report giving the mileage of all points of importance on the river from Wetumpka, Ala., and also from Greensport, Ala., these places being the extreme ends of the system of slackwater navigation under construction and proposed. From Greensport, Ala., to Lock No. 4, the initial point of the survey, is a distance of 25.89 miles, on which the work of improvement is approaching completion. The table also shows the length and rise in low-water surface of all the shoals and pools, both individually and collectively, the width of the river at each point, and at several points the highest rise attained by the water surface during floods over that of low water. This occurred during April, 1886, and was exceptionally high, much more so than has been known either before or since; but of course being always liable to recur, as the area of country drained by the river becomes more cleared and brought under cultivation; and that such is in progress is proved by the fact that the water of the Coosa River, formerly noted for its exceptionally clear qualities, is becoming more and more muddy each year. The table also shows the amount of channel work at the various points.

There is also attached a table giving the approximate quantities of materials, etc., and the cost of each lock, based upon the current prices for the same class of work in this and the neighboring States.

Respectfully submitted,

CHARLES FIRTH,
United States Assistant Engineer.

Capt. P. M. PRICE,
Corps of Engineers, U. S. A.

TABLE I.—*Table showing mileage from Wetumpka Bridge and from Greensport, of important points on the river, and rise of low-water surface at shoals and pools.*

[The "initial point" is the surface of mean low water at foot of Wetumpka Falls, and its elevation is 154.37 above assumed datum of the survey.]

Locality.	Mileage from—		Length of shoals and pools.*	Low-water surface.		High water of 1886 above mean low water.	Width of river at low water.	Channel work.
	Wetumpka bridge.	Greensport.		Difference of elevation.	Elevation above initial point.			
								Cu. yds.
Lock No. 31, 14-foot lift	—0.15	142.22					600	
Foot of Wetumpka Rapids	—0.15	142.22			0.00		600	
Wetumpka Bridge	0.0	142.07				53.40	600	
Foot of pool above	0.40	141.67	S. 0.55	11.45	11.45		750	
Corn Creek	1.95	140.12					750	
Foot of Corn Creek Shoals	2.00	140 07	P. 1.60	1.23	12.68		700	
Lock No. 30, 10-foot lift	2.00	140.07					700	
Foot of pool	2.65	139.42	S. 0.65	6.16	18.84		500	
Rast's Saw Mill (water gauge)	2.83	139.24					500	
Foot of Moccasin Shoals	3.30	138.77	P. 0.65	0.42	19.26		600	
Foot of pool above	3.75	138.32	S. 0 45	3.74	23.00		600	
Foot of Grey's Island shoals	4.63	137.44	P. 0.88	0.05	23.05		750	
Lock No. 29, 8-foot lift	4.65	137.42					750	
Foot of Grey's Island	4.89	137.18					1,200	
Rose's Creek	5.05	137.02					1,650	
Head of Grey's Island	5.25	136.82					1,650	
Foot of pool above	5.85	136.22	S. 1.22	8.70	31.75		600	
Buzzard Rock	7.00	135.07					550	
Lock No. 28, 12-foot lift	7.45	134.62					800	
Foot of succession of shoals	7.75	134.32	P. 1.90	0.66	32.41		950	
Sofkahatchee Creek	8.26	133.81				29.30	950	
Foot of Gunn's Island	8.35	133.72					1,050	
Head of Gunn's Island	8.79	133.28					1,450	
Lock No. 27, 14-foot lift	8.90	133.17					1,300	
Closet Reef	9.60	132.47					1,300	
Lock No. 26, 12-foot lift	11.65	130.42					2,000	1,320
Staircase Falls	11.75	130.32					2,000	
Shoal Creek	12.85	129.22					1,800	
Lock No. 25, 10-foot lift	12.92	129.15					1,800	
Foot of pool	13.60	128.47	S. 5.85	43.27	75.68		1,500	
Reef	14.82	127.25					750	
Grey's Ferry	15.34	126.73					650	
Town Creek	15.85	126.22					600	
Lock No. 24, 10-foot lift	16.30	125.77					750	
Foot of shoals	16.30	125.77	P. 2.70	6.95	82.63		750	
Welone Creek	16.78	125.29					900	
Foot of pool	17.51	124.56	S. 1,21	5.50	88.13		700	
Foot of shoal	18.50	123.57	P. 0.99	2.73	90.86		800	
Lock No. 23, 14-foot lift	18.50	123.57					800	
Foot of pool	19.00	123.07	S. 0.50	3.96	94.82		500	
Thompson's Ferry (disused)	19.25	122.82					450	
Foot of shoal	19.50	122.57	P. 0.50	0.72	95.54		750	
Foot of pool	20.15	121.92	S. 0.65	4.40	99.94		1,200	
Pinchoulee Creek	20.30	121.77					900	
Foot of Fish-trap Shoals (Hell's Gap)	21.35	120.72	P. 1.20	2.03	101.97		900	
Lock No. 22, 12-foot lift	21.40	120.67					900	
Proctor's Creek	22.04	120.03					1,250	
Chestnut Creek	22.56	119.51					1.300	
Foot of pool	23.40	118.67	S. 2.65	14.99	116.96		1,500	5,910
Knight's Ferry	23.98	118.09					600	
Lock No. 21, 10-foot lift	25.55	116.52					800	
Foot of Duncan's Riffle	25.55	116.52	P. 2.15	1.17	118.13		800	
Foot of pool	26 15	115.92	S. 0.60	7.04	125.17		700	
Blue Creek	27.19	114.88					800	
Smith's Ferry	28.65	113 42					700	
Cargals Creek	28.65	113.42					700	
Hatchet Creek	30.33	111.74					700	
Zimmerman's Ferry	31.32	110.75				49.28	700	2,500
Lock No. 20, 10-foot lift	31.50	110.57					900	
Foot of succession of shoals	31.50	110.57	P. 5.35	2.72	127.89		900	
Foot of House's Island	31.52	110.55					900	
Head of House's Island	32.50	109.57					1,050	
Foot of "Tuck-a-league" Shoals	33.40	108.67					1,000	
Lock No. 19, 12-foot lift	33.80	108.27					1,100	
Lock No. 18, 13-foot lift	34.75	107.32					1.500	
"The Suck"	34.98	107.09					1,600	
Head of Tuck-a-league Shoals	35.22	106.85					1,600	
Lock No. 17, 15-foot lift	36.05	106.02					1,300	270
Foot of Sauley Island	36.20	105.87					1,500	

* S., shoals; P., pool.

TABLE I.—*Table showing mileage from Wetumpka Bridge, etc.*—Continued.

Locality.	Mileage from—		Length of shoals and pools.*	Low-water surface.		High water of 1886 above mean low water.	Width of river at low water.	Channel work.
	Wetumpka bridge.	Greensport		Difference of elevation.	Elevation above initial point.			
Lock No. 17, 15-foot lift—Cont'd.								*Cu. yds.*
Foot of "Butting Ram" Shoal.	36.20	105.87	.....	.....	.....	.....	1,500	.....
Head of Sauley Island	37.12	104.95	.....	.....	.....	.....	2,300	.....
Foot of Pate's Island	37.12	104.95	.....	.....	.....	.....	2,300	.....
Lock No. 16, 14-foot lift	37.50	104.57	.....	.....	.....	.....	2,800	.....
Head of Pate's Island	38.20	103.87	.....	.....	.....	.....	2,200	.....
Head of "Butting Ram" Shoal	38.55	103.52	.....	.....	.....	.....	1,200	.....
Foot of Johnson's Island	38.64	103.43	.....	.....	.....	.....	1,400	160
Head of Johnson's Island	39.56	102.51	.....	.....	.....	.....	1,200	.....
Adam's Ferry	39.80	102.27	.....	.....	.....	.....	500	.....
Foot of Waxahatchee Shoals	39.85	102.22	.....	.....	.....	.....	1,000	.....
Lower Yellowleaf Creek	39.87	102.20	.....	.....	.....	.....	900	5,970
Lock No. 15, 10-foot lift	40.20	101.87	.....	.....	.....	.....	1,400	
Foot of Morgan's Island	40.99	101.08	.....	.....	.....	.....	1,200	.....
Head of Morgan's Island	41.25	100.82	.....	.....	.....	.....	1,400	.....
Paint Creek (lower mouth)	41.30	100.77	.....	.....	.....	.....	1,300	.....
Foot of Gentry Island	41.50	100.57	.....	.....	.....	.....	700	.....
Paint Creek (upper mouth)	41.60	100.47	.....	.....	.....	.....	900	.....
Head of Gentry Island	41.77	100.30	.....	.....	.....	.....	1,300	.....
Lock No. 14, 12-foot lift	41.90	100.17	.....	.....	.....	.....	1,500	.....
Foot of "Devil's Race"	42.00	100.07	.....	.....	.....	.....	1,600	.....
Foot of Cedar Island	42.16	99.91	.....	.....	.....	.....	2,000	.....
Head of Cedar Island	42.85	99.22	.....	.....	.....	.....	2,400	.....
Lock No. 13, 12-foot lift	43.00	99.07	.....	.....	.....	.....	2,300	.....
Head of "Devil's Race"	43.70	98.37	.....	.....	.....	.....	1,900	1,210
Lock No. 12, 10-foot lift	44.90	97.17	.....	.....	.....	.....	1,500	
Waxahatchee Creek	44.95	97.12	.....	.....	.....	.....	1,700	.....
Koaga Creek	46.05	96.02	.....	.....	.....	.....	2,300	800
Foot of pool at "The Narrows"	46.10	95.97	S. 14.60	106.74	234.63	.....	1,300	.....
"The Narrows"	46.34	95.73	.....	.....	.....	.....	400	.....
Foot of Weduska Shoal	46.45	95.62	P. 0.35	1.79	236.42	.....	1,300	.....
Lock No. 11, 10-foot lift	46.75	95.32	.....	.....	.....	.....	2,200	180
Foot of pool	47.45	94.62	S. 1.00	8.55	244.97	.....	1,000	
Slaughter Creek	48.52	93.55	.....	.....	.....	.....	900	.....
Wood's Ferry	49.15	92.92	.....	.....	.....	.....	1,000	.....
McGuire's Spring Branch	49.75	92.32	.....	.....	.....	.....	900	.....
Merrill's Ferry	51.93	90.14	.....	.....	.....	.....	950	.....
Peckerwood Creek	53.06	89.01	.....	.....	.....	.....	1,000	.....
Foot of Shoal	53.40	88.67	P. 5.95	0.46	245.43	.....	1,300	.....
Lock No. 10, 8-foot lift	53.55	88.52	.....	.....	.....	.....	1,350	1,290
Peckerwood Bar	53.60	88.47	.....	.....	.....	.....	1,350	.....
Sulphur Spring Branch	54.33	87.74	.....	.....	.....	.....	1,300	.....
Large Branch	54.40	87.67	.....	.....	.....	.....	1,300	.....
Fort William Ferry	54.99	87.08	.....	.....	.....	.....	1,050	.....
Cedar Creek	55.19	86.88	.....	.....	.....	.....	1.400	.....
Old Ford	55.38	86.69	.....	.....	.....	.....	1,450	.....
Lock No. 9, 8-foot lift	56.20	85.87	.....	.....	.....	.....	1,400	1,110
Kelly Branch	56.23	85.84	.....	.....	.....	.....	1,600	.....
Flat Branch	56.87	85.20	.....	.....	.....	.....	1,800	650
Foot of Pool	57.27	84.80	S. 3.87	12.93	258.36	.....	1,300	.....
Foot of Steam-boat Island	57.81	84.26	.....	.....	.....	.....	1,000	.....
Mud Creek	57.87	84.20	.....	.....	.....	.....	1,200	.....
Head of Steamboat Island	58.00	84.07	.....	.....	.....	.....	1,250	.....
Sally Branch	59.00	83.07	.....	.....	.....	.....	850	.....
Beeswax Creek	59.34	82.73	.....	.....	.....	.....	900	.....
Booley's Creek	60.17	81.90	.....	.....	.....	.....	750	.....
Pope Branch	60.21	81.86	.....	.....	.....	.....	750	.....
McRae's Ferry	60.82	81.25	.....	.....	.....	.....	460	.....
Foot of Three Island Shoals	62.10	79.97	P. 4.83	0.31	258.67	.....	860	1,660
Hay's Spring Branch	62.86	79.21	.....	.....	.....	.....	800	.....
Foot of Bullock's Island	63.07	79.00	.....	.....	.....	.....	960	2,210
Head of Bullock's Island	64.36	77.71	.....	.....	.....	.....	1,850	38,700
Foot of pool	65.10	76.97	S. 3.00	6.98	265.65	.....	800	.....
Oden's Ferry	65.72	76.35	.....	.....	.....	25.18	550	.....
Upper Yellow Leaf Creek	66.60	75.47	.....	.....	.....	.....	600	.....
Kahatchee Creek	68.00	74.07	.....	.....	.....	.....	900	.....
East Tennessee, Virginia and Georgia Railroad Bridge	68.07	74.00	.....	.....	.....	.....	850	.....
Foot of Island	72.98	69.09	.....	.....	.....	.....	800	.....
Foot of succession of shallows and pools	73.02	69.05	P. 7.92	0.92	266.57	.....	1,100	22,220
Head of island	73.35	68.72	.....	.....	.....	.....	1,000	.....

*S., shoals; P., pools.

TABLE I.—*Table showing mileage from Wetumpka Bridge, etc.*—Continued.

Locality.	Mileage from—		Length of shoals and pools.*	Low-water surface.		High water of 1886 above mean low water.	Width of river at low water.	Channel work.
	Wetumpka bridge.	Greensport.		Difference in elevation.	Elevation above initial point.			
								Cu. yds.
Lock No. 9, 8-foot lift Cont'd.—								
Chancellor's Ferry	74.10	67.97					650	
Foot of Prince's Island	74.10	67.97					700	
Head of Prince's Island	74.60	67.47					900	5,360
Savannah and Western Railroad bridge	75.23	66.84					600	
Tallassee-Hatchee Creek	75.72	66.35					750	
Foot of pool	76.05	66.02	S. 3.03	1.06	267.63		650	
Talladega Creek	76.65	65.42					500	1,980
Reef	79.72	62.35					600	920
Meyers Ferry	81.02	61.05					500	
Lower Clear Creek	81.15	60.92					550	
Foot of stretch of shoal water	81.20	60.87	P. 5.15	1.32	268.95		650	
Lock No. 8, 12-foot lift	81.25	60.82					650	
Foot of Hall's Island	82.41	59.66					750	
Head of Hall's Island	82.93	59.14					850	
Foot of pool	83.20	58.87	S. 2.00	3.45	272.40		700	
Spring Creek	84.67	57.40					600	
Glover's Ferry	84.71	57.36					600	
Foot of succession of shoals and shallow water	85.15	56.92	P. 1.95	2.83	275.23		700	
Foot of Ratcliffe's Island	85.23	56.84					750	
Head of Ratcliffe's Island	85.97	56.10					950	
Kelly's Creek	86.27	55.80					700	
Foot of Bell's Island	87.82	54.25					700	
Head of Bell's Island	88.28	53.79					950	
Lock No. 7, 10-foot lift	88.30	53.77					950	
Grissom's Ferry	90.24	51.83				21.80	900	
Foot of Vincents Island	90.27	51.80					950	
Head of Vincents Island	90.80	51.27					950	
Upper Clear Creek	91.77	50.30					600	
Foot of shoal	91.90	50.17	S. 6.75	13.84	289.07		600	
Lock No. 6, 10-foot lift	92.00	50.07					600	
Howells Mill	92.24	49.83					1,050	
Foot of Island	92.31	49.76					1,350	
Head of Island	92,77	49.30					1,250	
Large Creek	93.12	48.95					850	
Foot of Island	94.78	47.29					1,400	
Drake's Mill	94.80	47.27					1,400	550
Head of Island	95.34	46.73					1,350	
Griffith's Ferry	95.80	46.27					850	} 12,940
Foot of pool	96.55	45.52	S. 4.65	16.06	305.13		1,050	
Reef	98.32	43.75					1,050	4,860
Foot of Curry's Island	99.08	42.99					800	
Foot of shoal	99.35	42.72	P. 2.80	0.50	305.63		1,400	
Head of Curry's Island	99.60	42.47					1,200	10,920
Foot of pool	99.80	42.27	S. 0.45	0.75	306.38		550	
T. and C. V. R. R. bridge	101.13	40.94					550	
Collins Ferry	101.25	40.82					570	} 18,575
Saw-mill	101.48	40.59					580	
Reef	102.20	39.82					750	
Foot of Sheep Island	103.92	38.15					1,000	
Foot of Choccolocco Shoal	104.24	37.83	P. 4.44	5.50	311.88		1,300	
Lock No. 5, 8-foot lift	104.30	37.77					1,300	
Head of Sheep Island	104.34	37.73					1,300	
Foot of Ogletree's Island	104.36	37.71					1,300	
Howell's Branch	104.38	37.69					1,300	
Choccolocco Creek	104.95	37.12					2,300	
Head of Ogletree's Island	106.05	36.02					1,700	1,480
Foot of pool	106.35	35.72	S. 2.11	6.45	318.33		1,200	
Reef	107.25	34.82					800	3,960
Truss's Ferry and foot of shoal	108.03	34.04	P. 1.68	2.84	321.17	20.39	900	
Foot of Robertson's Island	108.05	34.02					950	} 8,773
Head of Robertson's Island	108.49	33.58					1,100	
Foot of pool	108.70	33.37	S. 0.67	0.58	321.75		800	
Empire Lumber Co.'s mills	108.87	33.20					600	
Reef	110.75	31.32					600	46
Blue Eye Creek	111.30	30.77					500	
Coleman's Ferry	112.48	29.59					600	
Georgia Pacific Railroad Bridge (River Side Station)	112.58	29.49				25.47	600	1,606
Blue Spring Branch	114.77	27.30					400	130
Embry's Ferry	115.35	26.72				27.69	650	} 4,620
Dam at Lock 4	116 18	25.89	P. 7.48	0.98	322.73		750	

*S., shoals; P., pools.

TABLE II.—*Estimated cost of a lock of the type proposed to be used having a lift of* 11 *feet, which is the average lift of the total number of twenty-seven locks.*

[The prices are based on the average of eight of the tenders received for the construction of Lock No. 7, Great Kanawha River, West Virginia, and include all cost of supplying, fitting, and placing the material in the locks.]

Class of work.	Quantities.	Rate.	Amount.
Coffer-dam			$15,000.00
Excavation ..... cubic yards	12,000	$0.78	9,360.00
Rock excavation ..... do	600	2.39	1,434.00
Embankment ..... do	8,000	.42	3,360.00
Puddling ..... do	400	1.20	480.00
Concrete ..... do	1,343	7.18	9,642.74
Backing masonry ..... do	6,556	7.55	49,497.80
First-class masonry ..... do	5,166	10.97	56,671.02
Coping and quoins ..... do	645	17.20	11,094.00
Miter-sills ..... do	76	15.45	1,174.20
Timber in guide cribs ..... feet, B. M.	61,000	40.25	2,455.25
Stone filling in cribs ..... cubic yards	2,816	1.88	5,294.08
Paving slopes ..... do	1,736	2.59	4,496.24
Bolt holes in masonry ..... linear feet	1,056	.34	359.04
Total			170,318.37

TABLE III.—*Estimate of cost of crib and stone dams.*

[Prices include cost of all labor for the completed dams.]

Height of dam.	Lumber, at $20 per M.		Iron drift-bolts, at 10 cents per pound.		Rock filling, at $2.50 per cubic yard.		Total cost per linear foot of dam.
	Feet, B. M., per linear foot of dam.	Amount.	Pounds per linear foot of dam.	Amount.	Cubic yards per linear foot of dam.	Amount.	
Feet.							
8	154	$3.08	8.0	$0.80	2.6	$6.50	$10.38
10	179	3.58	9.6	.96	3.3	8.25	12.79
12	249	4.98	12.8	1.28	4.0	10.00	16.26
14	277	5.54	14.4	1.44	4.7	11.75	18.73
16	337	6.74	17.5	1.75	5.4	13.50	21.99

TABLE IV.—*Estimate of cost of earthen dykes protected by stone.*

Height of dike.	Earth filling, at 50 cents per cubic yard.		Rock protection, at $2.50 per cubic yard.		Total cost per linear foot of dike.
	Cubic yards per linear foot of dike.	Amount.	Cubic yards per linear foot of dike.	Amount.	
Feet.					
6	1.77	$0.88	1.77	$4.42	$5.30
8	3.11	1.55	2.22	5.55	7.10
10	4.74	2.37	2.26	6.65	9.02
12	6.66	3.33	3.11	7.77	11.10
14	8.88	4.44	3.55	8.87	13.31

TABLE V.—*Estimate of cost of the proposed improvement of the Coosa River, between Wetumpka and Lock No. 4.*

No. of lock.	Lift.	Lock.	Dam.	Dike.	Abutment.	Gates, valves, etc.	Lock-house.	Channel work between locks at $2.50 per cubic yard.	Total.
	Feet.								
31	14	$187,532	$9,456	$9,020	$8,701	$11,302	$2,500	.....	$228,511
30	10	167,594	11,238	.....	4,350	8,073	2,500	.....	193,755
29	8	157,280	3,252	19,425	.....	6,458	2,500	.....	188,915
28	12	176,683	18,077	.....	8,701	9,687	2,500	.....	215,648
27	14	187,532	25,653	.....	4,350	11,302	2,500	.....	231,337
26	12	176,683	24,243	4,510	8,701	9,687	2,500	$3,300	229,624
25	10	167,594	27,642	.....	8,701	8,073	2,500	.....	214,510
24	10	167,594	13,293	.....	8,701	8,073	2,500	.....	200,161
23	14	187,532	17,592	.....	8,701	11,302	2,500	.....	227,627
22	12	176,683	16,857	.....	4,350	9,687	2,500	14,775	224,852
21	10	167,594	14,984	.....	.....	8,073	2,500	6,250	199,401
20	10	167,594	16,857	.....	8,701	8,073	2,500	.....	203,725
19	12	176,683	18,730	.....	.....	9,687	2,500	.....	207,600
18	13	181,239	28,095	.....	.....	10,495	2,500	.....	222,329
17	15	192,564	10,995	.....	8,701	12,109	2,500	675	227,541
16	14	187,532	15,393	.....	8,701	11,302	2,500	15,325	240,753
15	10	167,594	21,138	.....	8,701	8,073	2,500	.....	208,006
14	12	176,683	31,841	.....	8,701	9,687	2,500	.....	229,412
13	12	176,683	37,460	.....	.....	9,687	2,500	3,025	229,355
12	10	167,594	21,138	.....	8,701	8,073	2,500	2,000	210,006
11	10	167,594	16,236	.....	.....	8,073	2,500	450	194,853
10	8	157,280	17,906	.....	8,701	6,458	2,500	3,225	196,070
9	8	157,280	20,464	.....	8,701	6,458	2,500	187,025	382,428
8	12	176,683	13,111	.....	8,701	9,687	2,500	.....	210,682
7	10	167,594	14,634	.....	8,701	8,073	2,500	.....	201,502
6	10	167,594	11,382	.....	8,701	8,073	2,500	119,613	317,863
5	8	157,280	11,967	.....	8,701	6,458	2,500	51,538	238,444
Total	.....	4,665,772	489,634	32,955	169,668	242,183	67,500	407,201	6,074,913

APPENDIX R.

IMPROVEMENT OF THE HARBOR OF MOBILE, OF WARRIOR, TOMBIGBEE, AND BLACK WARRIOR RIVERS, ALABAMA, AND OF CERTAIN RIVERS IN MISSISSIPPI—IMPROVEMENT OF CHANNEL TO BILOXI BAY.

REPORT OF MAJOR A. N. DAMRELL, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1890, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

IMPROVEMENTS.

1. Mobile Harbor, Alabama,
2. Black Warrior River, Alabama.
3. Warrior and Tombigbee rivers, Alabama and Mississippi.
4. Noxubee River, Mississippi.
5. Pascagoula River, Mississippi.
6. Biloxi Harbor, Mississippi.
7. Pearl River, Mississippi, between Edinburgh and Carthage.
8. Pearl River, Mississippi, from Jackson to Carthage.
9. Pearl River, Mississippi, below Jackson.

EXAMINATIONS AND SURVEYS.

10. Warrior River, Alabama, from Tuscaloosa to Demopolis; Tombigbee River, Alabama and Mississippi, from its mouth up to Vienna, and Tombigbee River between Vienna and Cotton Gin.

11. Sipsey River, Alabama, from the Tombigbee River at Vienna to Texas, with a view of easy transportation of coal.

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., July 19, 1890.

SIR: I have the honor to forward herewith annual reports for the fiscal year ending June 30, 1890, for the works under my charge.

Very respectfully, your obedient servant,

A. N. DAMRELL,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers U. S. A.

R 1.

IMPROVEMENT OF HARBOR AT MOBILE, ALABAMA.

The improvement of the channel of the harbor at Mobile, Ala., was begun by the General Government in 1827, the depth of water then being 5½ feet through Choctaw Pass and 8 feet on Dog River Bar.

By act of Congress:	
May 20, 1826	$10,000.00
March 2, 1829	20,000.00
June 23, 1834	10,000.00
March 3, 1835	17,997.60
March 3, 1837	50,000.00
July 7, 1838	50,000.00
August 3, 1852	50,000.00
	207,997.60
By act of Congress March 3, 1857 (relief claim)	20,833.08
Total	228,830.68

The result obtained was a channel 10 feet deep and 200 feet wide through the pass, and the same depth, with an unknown width, over the bar. In 1860 the channel through the pass was found to have shoaled to 7½ feet, the depth of water on the bar remaining the same. No further improvement was attempted until 1870.

From 1870 to 1875 the following amounts were appropriated for the purpose of obtaining a depth of 13 feet:

By act of Congress:	
July 11, 1870	$50,000
March 3, 1871	50,000
June 10, 1872	75,000
March 3, 1873	100,000
June 23, 1874	100,000
March 3, 1875	26,000
Total	401,000

This amount was expended in dredging a channel 13 feet deep and 300 feet wide from the mouth of the Mobile River through Choctaw Pass, and 13 feet deep and 200 feet wide through Dog River Bar to the 13-foot curve in the bay. The work was completed in 1876 and the channel remained practically as it was dredged until operations were commenced under a new project to obtain a depth of 17 feet. In 1878 a survey was directed to be made in order to determine whether the existing channel could be improved to a depth of 22 feet, and for this purpose Congress, by act June 18, 1878, appropriated the sum of $10,000.

The survey was made and a report was submitted to the Chief of Engineers, suggesting several plans of improvement. In March, 1880, it was decided to continue the former improvement by dredging to a depth of 17 feet, with a uniform width of 200 feet, from the 17-foot curve in Mobile River to the curve of the same depth in the lower bay, the estimated cost being $820,000. From 1878 to June 30, 1887, the following amounts were appropriated:

By act of Congress:	
June 18, 1878 (survey)	$10,000
March 3, 1879	100,000
June 14, 1880	125,000
March 3, 1881	100,000
August 2, 1882	125,000
July 5, 1884	200,000
August 6, 1886	90,000
Total	750,000

Statement of work done under the above appropriations.

Date of act.	Name of contractor.	Contract price.	Cubic yards removed.	Commenced.	Completed.
		Cents.			
Mar. 3, 1879 June 14, 1880	George C. Fobes & Co	12.3	1,610,804	Feb. 19. 1881	Nov. 9, 1882
Mar. 3, 1881	G. L. Long	11.7	724,730	Mar. 21,1882	Jan. 24, 1884
Aug. 2, 1882	R. Moore	12.3	888,093	Jan. 24, 1883	Feb. 9, 1884
July 5, 1884	Tobias Burke	9.0	1,920,438	Sept.19,1884	June 15, 1886
Aug. 6, 1886	R. Moore	9.5	829,854	Oct. 2, 1886	Apr. 25, 1887
	Total		5,973,919		

The channel of 17-foot depth was opened to a width of 75 feet in 1882 and was widened to 180 feet in 1889 and practically completed.

During this time vessels have passed through with a maximum draught of 18 feet, but owing to a filling in the cut at the lower end the draught has been generally limited to 16 feet.

February 6, 1885, a project was submitted for the improvement of Mobile River and harbor, with a view to securing 23 feet depth of water by enlarging and deepening by dredging the channel, which, since 1870, has been deepened in that manner first from 9 to 13 feet, and then from 13 feet to 17 feet. The estimated cost of the 23-feet project is $1,980,000, made up as follows:

Completion of 17-foot channel (including removal of material filled in the cut), upon which the estimate for the 23-foot cut was based	$282,000
Dredging channel 280 feet wide on top of cut and central depth of 23 feet	1,500,000
Removing material that will fill in during progress of work on 23-foot channel	198,000
Total	1,980,000

For the preservation of improvement after its completion, $60,000 annually.

August 11, 1888, an appropriation of $250,000 was made for improving harbor at Mobile, Ala., continuing improvement on enlarged project for securing a channel 23 feet deep and 280 feet wide. Work was commenced under this appropriation in October, 1888, and continued to the middle of February, 1890, at which time a cut had been made 80 feet wide and from 19 to 20 feet deep from Mobile to where that depth practically existed in the lower bay.

The contractor was the Alabama Dredging and Jetty Company; the contract price 9 cents per cubic yard, measured in the scow; the plant, 2 clam-shell dredges, with 4 and 4½ yard buckets, 4 scows, and 2 tugs, and the amount of material removed by them 2,312,395.

Tabular statement showing the channel as dredged and its condition, June, 1890.

Locality.	Dredged 1881–1890.				Examinations.				
	From the initial point.	Length between clusters.	Width.	Central depth.	Cross-section at—	Top width.	June 1888. Maximum depth in cross-section.	June 1889. Maximum depth in cross-section.	June 1890. Maximum depth in cross-section.
	Miles.	*Feet.*	*Feet.*	*Feet.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*
Initial point at mouth of Mobile River or Chain Cluster No. 1.	.....	.....	145	19–20	Chain Cluster No. 1.	690	19	18.8	21.4
Chain Cluster No. 1 to Chain Cluster No. 2.	0.6	330	145	19–20	Chain Cluster No. 2.	650	19.4	20.1	21.6
Chain Cluster No. 2 to Upper Gap Light Stake.	0.45	2,080	145	18–19	Upper Gap Light Stake.	700+	21.2	21.1	20.5
Upper Gap Light Stake to Cluster No. 2.	0.64	978	245	18–19	Cluster No. 2.	700+	22.6	22.6	21.9
Cluster No. 2 to Chain Cluster No. 3.	1.07	2,259	155	18–19	Chain Cluster No. 3.	700+	20.2	21.1	20.4
Chain Cluster No. 3 to Lower Gap Light Stake.	1.48	2,182	155	18–19	Lower Gap Light Stake.	700+	20.4	19.9	20.3
Lower Gap Light Stake to Cluster No. 3.	1.96	2,565	145	19–21	Cluster No. 3.	700	18.9	22.4	22.2
Cluster No. 3 to Cluster No. 4 ...	2.46	2,603	145	19–21	Cluster No. 4.	700+	17.5	20.3	20.2
Cluster No. 4 to Cluster No. 5 ...	3.25	4,194	145	19–21	Cluster No. 5.	700	16.6	22.8	20.6
Cluster No. 5 to Cluster No. 6 ...	3.50	1,338	145	19–21	Cluster No. 6.	700+	17.6	22.6	20.8
Cluster No. 6 to Cluster No. 7 ...	4.02	2,735	145	19–21	Cluster No. 7.	700+	17.0	21.3	18.8
Cluster No. 7 to Cluster No. 8 ...	4.59	2,998	145	19–21	Cluster No. 8.	700+	18.8	21.9	19.6
Cluster No. 8 to Cluster No. 9 ...	5.09	2,654	145	19–21	Cluster No. 9.	700+	17.8	22.3	20.2
Cluster No. 9 to Cluster No. 10..	5.61	2,713	145	19–21	Cluster No. 10..	700+	17.0	21.7	20.8
Cluster No. 10 to Cluster No. 11..	6.11	2,655	145	19–21	Cluster No. 11..	700+	17.1	20.4	19.0
Cluster No. 11 to Cluster No. 12..	6.60	2,610	145	19–21	Cluster No. 12..	700+	16.5	20.2	19.0
Cluster No. 12 to Cluster No. 13..	7.08	2,501	145	19–21	Cluster No. 13..	700+	16.1	21.6	19.3
Cluster No. 13 to Cluster No. 14..	7.54	2,418	145	19–21	Cluster No. 14..	700+	16.2	21.4	19.4
Cluster No. 14 to Cluster No. 15..	8.03	2,625	145	19–21	Cluster No. 15..	700+	16.1	21.1	19.3
Cluster No. 15 to Cluster No. 16..	8.54	2,666	145	19–21	Cluster No. 16..	700+	16.3	20.6	19.3
Cluster No. 16 to Cluster No. 17..	9.03	2,591	145	19–21	Cluster No. 17..	700+	16.7	21.8	19.2
Cluster No. 17 to Cluster No. 18..	9.52	2,582	145	19–21	Cluster No. 18..	700+	16.5	20.4	19.1
Cluster No. 18 to Cluster No. 19..	10.01	2,616	145	19–21	Cluster No. 19..	700+	16.8	21.3	19.0
Cluster No. 19 to Cluster No. 20..	10.52	2,659	145	19–21	Cluster No. 20..	700+	16.5	16.8	19.7
Cluster No. 20 to Cluster No. 21..	11.00	2,580	145	19–21	Cluster No. 21..	700+	16.4	16.5	20.5
Cluster No. 21 to Cluster No. 22..	11.41	2,550	145	19–21	Cluster No. 22..	700+	16.4	15.9	19.6
Cluster No. 22 to Cluster No. 23..	11.99	2,590	145	19–21	Cluster No. 23..	700+	16.2	18.0	19.2
Cluster No. 23 to Cluster No. 24..	12.45	2,502	145	19–21	Cluster No. 24..	700+	16.1	17.9	19.5
Cluster No. 24 to Cluster No. 25..	12.94	2,560	145	19–21	Cluster No. 25..	700+	15.8	17.6	19.2
Cluster No. 25 to Cluster No. 26..	13.42	2,535	145	19–21	Cluster No. 26..	690+	15.7	17.2	18.7
Cluster No. 26 to Cluster No. 27..	13.91	2,592	145	19–21	Cluster No. 27..	700+	15.2	15.7	18.2
Cluster No. 27 to Cluster No. 28..	14.40	2,587	145	19–21	Cluster No. 28..	700+	15.9	15.5	18.4
Cluster No. 28 to Cluster No. 29..	14.99	2,620	145	19–21	Cluster No. 29..	700+	15.6	15.6	17.9
Cluster No. 29 to Cluster No. 30..	15.39	1,790	145	19–21	Cluster No. 30..	700+	15.9	15.8	18.3
Cluster No. 30 to Cluster No. 31..	15.91	1,790	145	19–21	Cluster No. 31..	700+	18.2	16.0	17.2
Cluster No. 31 to Cluster No. 32..	16.21	2,580	145	19–21	Cluster No. 32..	700+	14.8	18.5	17.7
Cluster No. 32 to Cluster No. 33..	16.71	2,650	185	19–21	Cluster No. 33..	700+	14.5	19.8	17.4
Cluster No. 33 to Cluster No. 34..	17.24	2,750	185	19–21	Cluster No. 34..	700+	14.4	19.3	16.7
Cluster No. 34 to Cluster No. 35..	17.75	2,725	185	19–21	Cluster No. 35..	700+	15.2	18.6	17.3
Cluster No. 35 to Cluster No. 36..	18.27	2,750	185	19–21	Cluster No. 36..	700+	14.4	19.3	16.6
Cluster No. 36 to Cluster No. 37..	18.77	2,615	185	19–21	Cluster No. 37..	700+	14.5	18.5	15.9
Cluster No. 37 to Cluster No. 38..	19.25	2,540	185	19–21	Cluster No. 38..	700+	14.8	18.9	16.5
Cluster No. 38 to Cluster No. 39..	19.76	2,695	185	19–21	Cluster No. 39..	700+	14.6	18.9	16.6
Cluster No. 39 to Cluster No. 40..	20.27	2,705	185	19–21	Cluster No. 40..	700+	14.4	18.4	15.9
Cluster No. 40 to Cluster No. 41..	20.69	2,227	185	19–21	Cluster No. 41..	700+	14.2	19.8	16.2
Cluster No. 41 to Cluster No. 42..	21.29	3,160	185	19–21	Cluster No. 42..	700+	14.2	19.0	15.8
Cluster No. 42 to Cluster No. 43..	21.83	2,824	185	19–21	Cluster No. 43..	700+	14.2	18.6	15.6
Cluster No. 43 to Cluster No. 44..	22.33	2,660	185	19–21	Cluster No. 44..	320	14.5	20.7	16.7
Cluster No. 44 to Cluster No. 45..	22.94	3,230	185	19–21	Cluster No. 45..	430	14.5	17.8	17.8
Cluster No. 45 to Cluster No. 46..	23.35	2,145	185	19–21	Cluster No. 46..	700+	15.0	16.5	17.5
Cluster No. 46 to Cluster No. 47..	23.89	2,865	185	19–21	Cluster No. 47..	700+	15.3	16.2	17.9
Cluster No. 47 to Cluster No. 48..	24.40	2,701	185	19–21	Cluster No. 48..	510+	15.5	17.0	18.3
Cluster No. 48 to Cluster No. 49..	24.94	2,833	185	19–21	Cluster No. 49..	600+	15.8	17.0	19.5
Cluster No. 49 to Cluster No. 50..	25.49	2,930	185	19–21	Cluster No. 50..	690+	16.8	17.7	20.4
Cluster No. 50 to Cluster No. 51..	25.91	2,210	185	19–21	Cluster No. 51..	700+	17.9	18.6	18.6

Money statement.

July 1, 1889, amount available	$4,476.03
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	1,967.78
July 1, 1890, balance available	2,508.25
Amount appropriated by act of September 19, 1890	350,000.00
Amount available for fiscal year ending June 30, 1891	352,508.25
Amount (estimated) required for completion of existing project	1,380,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	1,380,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

COMMERCIAL STATISTICS.

The following is a statement of the number and character of vessels of greater draught than 13 feet that have passed through the 17-foot channel without any material detention during the fiscal year ending June 30, 1889–'90.

Draught.	Steamers.				Ships.				Barks.				Brigs.				Schooners.				Total.			
	Up.		Down.		Up.		Down.		Up.		Down.		Up.		Down.		Up.		Down.		Up.		Down.	
	1889.	1890.	1889.	1890.	1889.	1890.	1889.	1890.	1889.	1890.	1889.	1890.	1889.	1890.	1889.	1890.	1889.	1890.	1889.	1890.	1889.	1890.	1889.	1890.
13 to 14 feet	..	16	..	5	..	4	....	....	11	16	1	1	..	..	2	....	4	..	28	31	15	36	31	37
14 to 15 feet	..	3	....	5	5	3	....	....	11	14	3	2	..	..	2	1	2	3	34	29	18	23	39	37
15 to 16 feet	2	..	2	21	..	1	6	....	3	2	45	10	..	..	....	2	..	3	29	28	5	6	82	61
16 to 17 feet	1	1	17	14	..	..	....	10	3	1	21	88	..	..	....	3	..	..	6	16	4	2	44	131
17 to 17½ feet	..	..	1	3	..	..	....	....	..	..	1	9	..	..	....	....	..	..	....	4	..	..	2	16
17½ to 18 feet	..	..	....	....	..	..	....	....	..	..	....	....	..	..	....	....	..	..	....	4	..	..	....	4
Total	3	20	20	48	5	8	6	10	28	33	71	110	..	..	4	6	6	6	97	112	42	67	198	286

Comparative statement of timber, lumber, etc, shipped by vessels to foreign and coastwise ports.

Description.	1890.	1889.	1888.	1881.
	Quantity.	Quantity.	Quantity.	Quantity.
Lumber:				
Foreign.....tons..	87,364	28,278	49,525	15,375
Coastwise.....do...	11,792	34,214	.....	12,783
Total	99,156	62,492	49,525	28,158
Timber:				
Foreign.....tons..	33,992	39,182	26,893	27,101
Coastwise.....do...	.....	1,144	.....	1,744
Total	33,992	40,326	26,893	28,845
Shingles:				
Foreign.....tons..	135	90	109	866
Coastwise.....do...	154	24	.....	480
Total	289	114	109	1,346
Staves:				
Foreign.....tons..	504	2,588	78	831
Coastwise.....do..	.....	392	.....	.....
Total	504	2,980	78	831

The following statistical statement for the year 1889–90 was furnished by the collector of customs of this port:

Description.	Entrances June 30, 1890.			Entrances June 30, 1889.			Clearances June 30, 1890.			Clearances June 30, 1889.		
	No.	Tons.	Crew.	No	Tons.	Crew.	No.	Tons.	Crew.	No.	Tons.	Crew.
Foreign.....	144	98,382	1,967	103	67,091	1,409	251	107,078	2,171	103	68,629	1,420
Coastwise ...	82	50,819	1,509	67	32,286	645	66	34,649	660	82	35,831	663
American....	81	29,056	610	61	20,851	466	69	19,235	497	54	15,212	407
Total ..	307	178,257	4,086	231	120,228	2,520	386	160,962	3,328	239	119,672	2,490

Imports and exports.

Description.	1890.	1889.
Duties on imports	$5,556.74	$12,215.52
Tonnage dues	6,317.69	4,028.58
Hospital collections	267.00	624.00
Miscellaneous	221.43	3,311.20
Total collections	12,372.86	20,179.30
Exports to foreign ports	3,371,298.00	3,192,997.00
Imports of foreign goods, values:		
Free	90,169.00	128,209.00
Dutiable	6,654.00	25,653.00

Comparative statement of cotton exported from Mobile, Ala.:

From September 1, 1888, to July 1, 1889	tons..	12,624
From September 1, 1889, to July 1, 1890	do...	11,197

R 2.

IMPROVEMENT OF BLACK WARRIOR RIVER, ALABAMA, FROM TUSCALOOSA TO DANIELS CREEK.

Act of 23d of May, 1828, declared Black Warrior River, Alabama, free from all tolls except such as might be allowed by act of Congress. (Sec. 5244 R. S., edition of 1878, page 1015.)

An examination and partial survey of the river from Locust Fork to its mouth, 47½ miles, was made in 1874 in accordance with provisions of act of Congress approved June 23, 1884, report of which is contained in Report of Chief of Engineers for 1875.

The survey of the Black Warrior River from Tuscaloosa to forks of Sipsey and Mulberry, 92¼ miles, was made in the fall of 1879, as provided for by act of Congress approved March 3, 1879, and the report thereon is contained in Report of Chief of Engineers, 1881, Part II, page 1218.

Appropriations have been made as follows:

By act of July 5, 1884	$50,000
By act of August 5, 1886	56,250
By act of August 11, 1888	100,000
	206,250

Under the first appropriation a survey for locating works of improvement and for obtaining data upon which to base details of plans

and estimates was commenced in September, 1884, and a report proposing a system of improvement by locks and movable dams was submitted December 19, 1885.

A Board of Engineers for considering the report and project met in Tuscaloosa February 10, 1886, and recommended locks and fixed dams. Plans and estimates for the project recommended were submitted August 13, 1886, and with certain modifications were accepted by the Board in their report dated April 2, 1887.

The extent of the work is the construction of five locks and dams between Tuscaloosa and Daniels Creek, 14¾ miles, and its purpose is to finish slackwater navigation for barges of 6 feet draught.

The locks are to be 52 feet clear width, 322 feet long between hollow quoins, and to have a depth of 6½ feet on miter-sills.

The estimated cost was $741,670, which will be probably exceeded, as the rock used in construction is found both in quarrying and working more expensive than was anticipated.

The project was approved May 19, 1887. The land required on the east side of the river was deeded to the United States by the board of mayor and aldermen of the city of Tuscaloosa, Ala., in November, 1887. A lock tender's house to serve as engineer's office during construction was contracted for and completed in May, 1888, at a cost of $1,990. Work was commenced in March, 1888. For the fiscal year ending June 30, 1888, the work done was preparatory, viz, clearing and grading lock-site, building necessary sheds and quarters, commencing track to quarry, stripping quarry, etc. During the fiscal year ending June 30, 1889, the preparatory was finished, comprising 1¾ miles of track to the quarry, 2 inclines into the lock-chamber, forming a circuit for delivering stone, coffer-dam 7 to 12 feet high and 550 feet long completed, 19 derricks framed and put up, bank excavation for lock-wall finished, and a derrick-boat and 2 barges built.

The work of construction proper during the year was:

	Cubic yards.
Stone quarried	7,811
Stone cut	2,364
Stone laid	1,434
Rock excavation in foundation	816
Earth excavation in foundation	1,500

During the fiscal year ending June 30, 1890, the work done was:

	Yards.
Masonry laid	7,262
Dry masonry laid	248
Stone cut	950
Stone quarried	4,100
Rock excavated in lock chamber	1,541
Earth excavated for bank wall	3,780
Rock placed in dam	800
Rock placed behind bank wall	600
Earth placed behind bank wall	941
Trestles for needle dam constructed	5

The rock-reef on which the lock rests was found so much cut up by crevices that it was found necessary to carry lock, miter, and needle-dam walls down to the bottom of the lock-chamber, thereby increasing the amount of masonry 1,390 yards over the original estimate.

The present condition of the work is as follows: The river-wall of Lock No. 1 is complete except the placing of six pieces of coping, the bank-wall is completed to a height of 24 feet (6 feet below top). Breast wall for needle dam is completed and trestles constructed. Lift wall

87 yards laid (66 yards to be laid). Lock chamber excavated except 1,000 yards. Base of dam commenced. Lock-tender's house built. There is no business done on the Black Warrior River at present, but if the improvements were completed it is safe to say that over 1,000,000 tons of coal would be shipped by this river annually, and the saving to consumers on or near the Gulf of Mexico would be at least $1,000,000 annually on this one item. There would be also developed a large commerce in iron ore, iron, stone, etc. The Government would be benefited directly by cheap coal and iron on the coast.

Money statement.

July 1, 1889, amount available		$62,244.69
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$54,044.41	
July 1, 1890, outstanding liabilities	3,343.12	
		57,387.53
July 1, 1890, balance available		4,857.43
Amount appropriated by act of September 19, 1890		150,000.00
Amount available for fiscal year ending June 30, 1891		154,857.43
Amount (estimated) required for completion of existing project		385,420.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		385,420.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

R 3.

IMPROVEMENT OF WARRIOR AND TOMBIGBEE RIVERS, ALABAMA AND MISSISSIPPI.

WARRIOR RIVER.

The examination and partial survey of the river from Tuscaloosa to Demopolis was made in 1874, and report thereon may be found in the Report of the Chief of Engineers of 1875, Part II, page 16.

In its original condition the river was well adapted for high-water navigation, having a width of 400 feet at Tuscaloosa, gradually diminishing to 150 feet near its mouth. The boating stage usually lasted five months, from December 1 to May 1, the depth ranging from 10 to 40 feet and the only obstructions encountered were overhanging trees, which sometimes carried away the chimneys of steam-boats and damaged their upper works. Below a 10-foot stage, snags became troublesome, and below 5 feet navigation practically ceased.

The obstructions to low-water navigation were:

(1) Ninety-four bars and reefs that afforded a ruling depth of 12 to 30 inches.

(2) Numerous snags and sunken logs, choking up the bar chutes and frequent in the reaches also.

(3) Overhanging trees that effectually closed narrow chutes even if otherwise open.

The improvement of the Warrior was authorized by act of Congress of March 3, 1875, and the project adopted was to deepen the bars by jetty construction, remove snags and cut down overhanging trees with

a view to obtaining for small boats a low-water channel 80 feet wide by 4 in depth.

The estimated cost of the improvement was $151,103.

Appropriations have been made as follows:

Warrior and Tombigbee rivers:		Warrior—Continued:	
March 3, 1875	$25,000	August 2, 1882	$10,000
August 14, 1876	15,000	July 5, 1884	12,000
June 18, 1878	28,000	August 5, 1886	18,750
March 3, 1879	20,000	August 11, 1888	18,000
Warrior:			
June 14, 1880	20,000	Total	177,372
March 3, 1881	10,622		

Of this amount $89,372 was appropriated for the Warrior, and $88,000 for Warrior and Tombigbee jointly. The execution of the project was commenced in June, 1875, and has been continued for an average annual period of four months up to November 10, 1885, and for three months in 1887, the work being confined chiefly to the removal of snags and overhanging timber, 9,700 snags, logs, and stumps and 9,000 overhanging trees having been removed. Channel deepening by jetty construction was also attempted upon forty-nine of the bars affording the shoalest water.

The work in 1887 was done by contract. The work of removing snags and logs has been repeated several times over a great part of the river. This has been made necessary from the fact that land slides and caving banks every year throw many trees into the river that, anchored by their roots, obstruct the channel. This trouble will continue until stability shall have been given to the yielding banks. The work of sloping and revetting needed for this purpose was not originally contemplated, but as the necessity for it became apparent, an experimental section 3,000 feet long was tried in 1886, costing at the rate of $6,000 per mile. This has proved satisfactory.

The practical results thus far accomplished may be stated as having lowered the navigable stage 3 feet; a boat with 600 bales of cotton, and drawing 4½ feet, passed down the river without difficulty on a stage barely 2 feet above low water.

Better results than this could not be expected in continuing the old project, because the slope on portions of the river is such that the low-water discharge will not give a uniform depth of more than 2½ feet in a channel of 80 feet width. Moreover, the statement as to the results obtained holds good only in the fall, because the low-water chutes around the bars lie out of the current during high water, and consequently fill up. The scouring-out process does not keep pace with the fall of the river surface in the spring, and it is not until late in the summer that the chutes become fully opened.

From the above it is evident that to secure a 4-foot low-water channel of navigable width, a different project from the one heretofore worked under had to be adopted, and when the improvement of the Black Warrior River above Tuscaloosa was undertaken for the benefit of the recently-developed mineral business of the Upper Warrior Basin, it was evident that the 6-foot low-water depth adopted in that project should be extended throughout the river below.

These facts being recognized, a survey of the Warrior was authorized from Tuscaloosa to the mouth, in order to get the data necessary for preparing plans and estimates for the improvement of the river on the scale desired.

This survey was commenced in the summer of 1887 and completed in

the fall of 1889, and a report was submitted December 24, 1889, proposing a plan of improvement to obtain a good channel with a minimum depth of 6 feet at low water by a system of dams and pneumatic gates in connection with snagging, cutting of overhanging trees, bank revetment and bar improvement, at an estimated cost of $577,000.

Since that time a more careful study of the data obtained by the survey has resulted in a change in the views previously entertained, and a belief that locks similar in size and general construction to those above Tuscaloosa will be better than the pneumatic gates, and can be used. This will furnish the subject of a special report to be submitted as soon as possible.

The work on the river during the fiscal year was confined to the removal of a raft of drift which had collected at what is known as the Forrest Piers. The balance of the money available being used in the preparation of a portion of a suitable plant for future use in the improvement of the river, the old plant having been completely used up and an attempt to do the work by contract having resulted in the conviction that it was more economical and advantageous to do the work by days' labor.

Money statement.

July 1, 1889, amount available		$17,678.63
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$3,710.65	
July 1, 1890, amount covered by uncompleted contracts made during fiscal year ending June 30, 1890	13,235.11	
		16,945.76
July 1, 1890, balance available		732.87
Amount appropriated by act of September 19, 1890		100,000.00
Amount available for fiscal year ending June 30, 1891		100,732.87
Amount (estimated) required for preservation of improvement		8,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892 (supposing the project for 6-foot channel be approved)		250,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

COMMERCIAL STATISTICS.

Articles.	1890.	1889.
Cotton ..... tons..	3,364	2,436
Grain ..... do...	285	791
Iron ..... do...	17	16
Lumber ..... do...	.....	18
General merchandise ..... do...	1,011	588
Total	4,677	3,849

TOMBIGBEE RIVER, FROM WALKER'S BRIDGE TO FULTON.

The examination of this section of the Tombigbee River was provided for by the river and harbor act of March 3, 1881, and again by the river and harbor act of August 5, 1886. An examination was made under the first act and a report was submitted February 10, 1882, which is contained in the Annual Report of the Chief of Engineers for 1882.

Under the second act reference was made to the examination previously made.

River and harbor act of August 11, 1888, appropriated $4,000 for the work.

The projected improvement is the opening of a channel for high-water navigation from Fulton up to Walker's Bridge by the removal of snags and overhanging trees, at an estimated cost of $11,000. Work was commenced at Fulton on November 17, 1888, and continued to December 21, 1888, when work was suspended on account of high water. It was resumed as soon as the stage of water would permit, March 15, 1889, and continued to the middle of August, 1889, at which time a point called Stevens' Field was reached, the river being thoroughly cleared between this point and Fulton, over one-half of the entire distance.

The results obtained by the improvement are as follows over that portion improved. Rafts of timber, of much larger size than formerly, can be floated down without breaking them up, as was formerly necessary on a stage of water 3½ feet above low water, and barges 80 feet long, 22 feet beam, and 4 feet draught, can be used when the water is 5 feet above low water.

It is estimated that the saving in freight and expense of transportation on cotton and timber and other supplies will be not less than $12,000 annually.

The length of this section of the river as given in the report of the preliminary examination (25 miles) is much too small.

The commerce on this section of the river during the last year is as follows:

	Tons.
Lumber	2,426
Cotton	88
Total	2,514

Money statement.

July 1, 1889, amount available	1,323.28
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	1,057.98
July 1, 1890, balance available	265.30
Amount appropriated by act of September 19, 1890	4,000.00
Amount available for fiscal year ending June 30, 1891	4,265.30
Amount (estimated) required for completion of existing project	3,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	3,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

TOMBIGBEE RIVER FROM FULTON TO VIENNA.

A survey of that portion of this section of the river from Fulton down to Columbus, 144 miles, was made under the act of June 10, 1872, and report of same submitted September 20, 1873. This report is contained in the Annual Report of the Chief of Engineers for 1873.

An examination was made of the remaining portion, 65 miles, under the act of July 11, 1870, report upon which is contained in Annual Report of the Chief of Engineers for 1871.

Previous to improvement navigation was carried on only during the winter (high water) season, and was seldom attempted above Aberdeen, 112 miles below Fulton. Snags, sawyers, and stumps obstructed the

channel in low stages so that navigation practically ceased on a stage 6 feet above low water below Columbus and 12 feet above. Overhanging trees were troublesome at all stages and frequent cause of damage. The normal width of the river on a navigable stage was from 80 feet at Fulton to 150 feet at Vienna.

The project adopted for this division was to improve high-water navigation from Columbus to Fulton by removing all timber obstructions above the low-water plane and to clear the banks of overhanging trees. From Columbus to Vienna, besides clearing the river-bed and banks of obstructions, it was proposed to deepen the bars by dikes and jetties so as to increase the depth of them (12 inches to 13 inches) to 3 feet, with a width of 40 feet.

The estimated cost of the improvement of the entire river was $205,000.

The amounts appropriated for this division, and specially designated in appropriations made for the Warrior and Tombigbee, have been—

By act of—	
March 3, 1873	$10,000
June 18, 1878	12,000
March 3, 1879	10,000
June 14, 1880	16,000
March 3, 1881	7,365
August 2, 1882	7,500
July 5, 1884	10,000
August 5, 1886	7,500
August 11, 1888	6,500

Work was commenced in August, 1878, and continued annually during portions of each year until May 12, 1888.

The work accomplished has been as follows: From Fulton to Columbus the project has been completed as designated and navigation secured down to a stage 4 feet above low water, but needs working over again. Below Columbus 5,130 snags, stumps, and sunken logs have been removed, overhanging trees cut, and twenty bars deepened to 3 feet, leaving fifteen unimproved. This section also needs working over again. The effect of the improvement has been to afford a navigable channel from Columbus to Vienna for boats drawing 3 feet with the river 2 feet above low water. Another foot can be gained by improving the unworked bars on the plan heretofore adopted, but the results obtained from the deepened bars show that they will not generally maintain the 3 feet required, and a 2-foot low-water channel is all that can be expected from the scouring method heretofore used.

The cost of maintaining the improved condition would be about $8,000 annually.

A survey of the river from Columbus to Vienna was made in 1887, and report with project and estimates for a channel of 6 feet depth at low water was submitted December 24, 1889.

Work during the year has been confined to the preparation of part of a plant for future operations.

Money statement.

July 1, 1889, amount available		$6,535.64
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$2,560.15	
July 1, 1890, amount covered by uncompleted contracts made during the fiscal year ending June 30, 1890	3,975.49	
		6,535.64
Amount appropriated by act of September 19, 1890		6,000.00

Amount (estimated) required for preservation of improvement.....	$8,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	8,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

TOMBIGBEE RIVER, BELOW VIENNA.

An examination of this portion of the river, 275 miles, was made under the act of July 11, 1870, report upon which is contained in Annual Report of the Chief of Engineers for 1871.

From Vienna to Demopolis (91 miles) the original condition of the river for navigation purposes was similar to that already described as that existing between Vienna and Columbus, and the same project for improvement was adopted. The width ranged from 150 to 200 feet.

Below Demopolis the river, with discharge from the Warrior added, increased in width to 300 feet and below Coffeeville to 500 feet, but with little gain in depth on the bars. In fact low-water navigation could be relied on only as high up as Bladon, 143 miles from Mobile.

Snags were very numerous, and at some points could be passed through only in daylight.

The project adopted was to clear the river of snags and secure a 4-foot channel of navigable width through the bars by jetty construction.

The estimated cost for the entire river (including upper division) was $205,000.

Appropriations have been made as follows:

Warrior and Tombigbee:	
March 3, 1875	$25,000
August 14, 1876	15,000
June 18, 1878	28,000
March 3, 1879	20,000
Tombigbee River, below Vienna:	
June 14, 1880	15,000
March 3, 1881	8,013
August 2, 1882	12,500
July 5, 1884	15,000
August 5, 1886	11,250
August 11, 1888	6,000

Work was commenced in 1873, and has continued annually for an average period of five months up to October 20, 1885, and for six weeks in 1887.

The work accomplished has been in the main the removal of snags and leaning timber; 5,232 snags have been taken out and trees cut away. Much of this work has been done in the annual revision made necessary by obstructions caused by caving banks. Fifteen bars above Demopolis have also been deepened to a depth of $2\frac{1}{2}$ to 3 feet and six below to a depth of $3\frac{1}{2}$ to 4 feet.

The improvement thus far made has afforded safe navigation to Demopolis at low water for boats drawing $2\frac{1}{2}$ feet and to Kirkpatricks, 267 miles from Mobile, for boats of 2-feet draught. Beyond this a rise of 2 feet is needed to carry boats of 3-feet draught to Vienna. The depths gained upon the improved bars are well maintained, but the channels are narrow and crooked so that the full depth is not available. Below Bladon three bars have formed of late years that do not afford more than $2\frac{1}{2}$ feet at low tide.

The necessity of a deeper channel than that originally contemplated applies to this river for the same reason as that given in the report for

the Warrior. To obtain the data needed for preparing plans and estimates for this deeper channel, a survey was commenced in 1887 and completed in winter of 1889 and report submitted December 24, 1889.

During the past fiscal year operations have been confined to preparing a part of a plant required for future work.

COMMERCIAL STATISTICS.

Articles.		1890.	1889.
Cotton	Tons	8,982	11,489
Grain	do	3,590	.....
Iron	do	54	247
Lumber	do	32,388	4,522
General merchandise	do	12,854	2,684
Total		57,868	18,942

Money statement.

July 1, 1889, amount available	$4,580.62
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July, 1889	4,311.26
July 1, 1890, balance available	269.36
Amount (estimated) required for preservation of improvement	8,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	500,000.00*
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

* Supposing the project for 6-foot channel to be approved.

R 4.

IMPROVEMENT OF NOXUBEE RIVER, MISSISSIPPI.

The examination of this river, provided for by act of Congress approved March 3, 1879, was made during the month of March, 1880, and extended from Macon, Noxubee County, Miss., to its mouth.

Report is contained in the Annual Report of the Chief of Engineers for 1880. The condition of the river when examined was such that during all seasons of the year, and at all stages of water, navigation, except by small flat-boats, was practically impossible. Steam-boats prior to the building of the Mobile and Ohio Railroad (1859) plied the river. After the construction of this railroad the boats were withdrawn. The river-banks then became overgrown with timber, much of which in time fell or slid into the river and caused the formation of a number of shoals and bars. The river being virtually abandoned for the purpose of navigation, the planters living along its banks assisted in obstructing its channel-way by building a number of fish-traps and mill-dams.

The chief obstruction to navigation consisted in the immense number of trees overhanging the river throughout its entire length. At the time of the examination the minimum depth of the river was found to be (at ordinary low-water) 1½ feet, and the average width 60 feet.

The project adopted was to afford a navigable channel during high-water, or about five months, to the town of Macon by the removal of

overhanging timber from the banks and such obstructions to navigation as might be found in the river.

The estimated cost was $65,245.25.

The appropriations made for the improvement are as follows:

By act of Congress—	
June, 14, 1880	$12,000
March 3, 1881	8,000
August 2, 1882	10,000
July 5, 1884	7,500
August 5, 1886	7,500
August 11, 1888	5,000
Total	50,000

Work was commenced on the improvement during the low-water season of 1880, prosecuted during the fiscal year ending June 30, 1881, and June 30, 1882, through the month of March, 1883, from September, 1884, to January 12, 1885; from May 23, 1885, to September 23, 1885; from May 26, 1887, to December 15, 1887; from May 15, 1888, to July 20, 1888; from September 20, 1888, to December 8, 1888, and from April 1, 1889, to October, 1889.

The following is a summary of work performed during the fiscal year:

Snags and logs removed	2,019
Trees pulled	253
Logs blasted	203
Yards of bank cleared of willow	5,190

The condition of the improvement at the end of the fiscal year is a completely improved channel from the mouth of the river up to Macon, 91½ miles, and the project may be considered to be completed.

The amount available and any appropriation that may be made will be applied to the maintenance of improvement in accordance with the present project.

The river during high water is navigable from its mouth to Macon. This work will require an annual expenditure of $3,000 to maintain it in its improved condition, and no further improvement should be considered until the Tombigbee River below Gainesville is completely improved.

The reduction in freight charges on cotton and produce by railroad, due to the improvement of the river, is estimated at not less, and probably much more, than $20,000 per annum.

Money statement.

July 1, 1889, amount available		$2,472.48
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889		2,185.02
July 1, 1890, balance available		287.46
Amount appropriated by act of September 19, 1890		3,000.00
Amount available for fiscal year ending June 30, 1891		3,287.46
Amount that can be profitably expended in fiscal year ending June 30, 1892		3,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

R 5.

IMPROVEMENT OF PASCAGOULA RIVER, MISSISSIPPI.

By act of—

March 2, 1827, an appropriation was made of	$8,000
May 23, 1828, an appropriation was made of	17,500
August 30, 1852, an appropriation was made of	5,000

The first appropriation was made for removing obstructions from the river and deepening the channel at its mouth; the second one was made for deepening the channel at its mouth; and the third was made for a survey of the river. There are no records in this office of the work done under these appropriations.

In 1870, March 1, a canal (called Noyes Canal) dredged across the bar at the mouth of the river, under a charter from the State of Mississippi to Abram A. Green, to a depth sufficient to admit vessels of 6 feet draught at low tide, was opened by private parties.

The cost of the canal was stated to be $27,000, and for annual maintenance $4,000.

By the act of March 3, 1873, a survey was directed to be made at East Pascagoula Harbor, Mississippi Sound. This survey was made during the same year and report was submitted October 23, 1873. The report is contained in the Annual Report of the Chief of Engineers for 1874.

The plan adopted for the improvement was the dredging of a channel 200 feet wide and 7 feet deep at mean low water through the bar at the mouth of the river, and the removal of snags and overhanging trees throughout its entire length at an estimated cost of $53,800.

The following appropriations were made to carry out this project:

By act of—

June 18, 1878	$10,000
March 3, 1879	14,000
June 14, 1880	20,000
March 3, 1881	4,000
August 2, 1882	8,000
July 5, 1884	3,000
Total	59,000

At the commencement of the work there was 3 feet on the crest of the bar at mean low water, and the river was much obstructed by snags, logs, and overhanging trees.

Of the aggregate amount of the several appropriations made up to July 5, 1884, less $1,500 allotted for examination, $42,500 was devoted to dredging through the bar at the mouth, and resulted in securing a channel through the bar 180 to 190 feet wide, 7½ to 8 feet deep.

Fifteen thousand dollars of the amount appropriated up to that time was applied to the removal of snags, logs, and overhanging trees. Commencing at the light-house, near the mouth of the river, in the spring of 1882, the work was prosecuted during the working season of 1882, 1883, 1884.

This portion of the work was completed on December 23, 1884, and resulted in securing a navigable channel from the mouth of the river to one-half mile above "Dead Lake," 50½ miles, for vessels drawing 6½ feet and to the junction of the Leaf and Chickasaha for vessels of lighter draught, during six or eight months of the year. The project was then virtually completed.

By act of—

August 5, 1886, an appropriation was made of	$20,000
August 5, 1886, transferred amount appropriated for improving Horn Island Pass, act of July 5, 1884	5,000
August 11, 1888, an appropriation was made of	27,000
	52,000

Under these appropriations a new project was proposed and approved for securing a channel of navigable width and minimum depth of 12 feet from Moss Point to the anchorage in the bay, at an estimated cost of $78,100 and maintaining the river above Moss Point in its improved condition. After due advertisements bids for dredging were opened August 17, 1887, and a contract entered into with J. H. Gardner September 15, 1887.

Dredging operations were commenced October 8, 1887, and completed April 28, 1888; 113,529 cubic yards were removed. The wreck of the United States snag-boat, sunk opposite Moss Point, was removed during May, 1888. Bids for improving Pascagoula River, Mississippi (dredging and building dam), were received and opened November 27, 1888, but prices (17½ cents for dredging and $3,700 for dam) were not satisfactory, and it was deemed best to defer any further action until it was determined by careful investigation whether more satisfactory results and a considerable saving might not be obtained by the purchase of a proper plant and the performance of the work by days' labor, especially as it was not believed that commerce would suffer to any extent, there not being a sufficient amount available to give a greater depth-way through than already existed, and even if the conclusion was to do the work by contract it was believed that more favorable terms might be obtained when by another appropriation the amount available might be increased. The time elapsing would be of value in determining the permanence of the improvement, concerning a portion of which there was considerable doubt.

Bids were again solicited and opened January 20, 1890, and that of George C. Fobes & Co., for dredging, at 16.2 cents per cubic yard, and of the Alabama Dredging and Jetty Company, for the dam, $3,350, accepted and contracts entered into.

Dredging was commenced April 16, 1890, and continued to the close of the fiscal year, at which time 52,685 yards had been removed, giving a channel 80 feet wide and 12 feet deep through Delmas Flats, and of same width and depth nearly through the shoal at Lowry Island. At the beginning of the work under the new project there was a depth of 7 feet through the bar at the mouth of the river obtained by dredging under the previous project, and a least depth of 9 feet in the river up to Moss Point.

Under the new project the work under the first contract was devoted to deepening the cut through the bar at the mouth of the river, and a channel of navigable width and 9½ feet depth obtained. Under the second contract operations were carried on in the river between Moss Point and the mouth, and about one-half the work necessary to obtain a channel 12 feet deep and 80 feet wide performed. The improvement will not be permanent in its character; $2,500 will be required annually for the removal of snags, etc., in order to maintain the river above Moss Point in its present improved condition.

The annual amount necessary to preserve the dredged channel can not at present be estimated.

The amount estimated for completion is in excess of the original estimate, the reasons for which are that, owing to the extra hardness of a

portion of the bottom to be dredged and the smallness of the appropriation made available, the cost of excavation is in excess of that originally estimated.

Money statement.

July 1, 1889, amount available		$27,004.07
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$6,242.64	
July 1, 1890, outstanding liabilities	4,665.43	
July 1, 1890, amount covered by uncompleted contracts made during fiscal year ending June 30, 1890	14,796.00	
		25,704.07
July 1, 1890, balance available		1,300.00
Amount appropriated by act of September 19, 1890		20,000.00
Amount available for fiscal year ending June 30, 1891		21,300.00
Amount (estimated) required for completion of existing project		69,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		50,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

Vessels.	1890.				1889.				1880.			
	Entrances.		Clearances.		Entrances.		Clearances.		Entrances.		Clearances.	
	No.	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*
Foreign	139	93,792	136	62,067	136	96,017	128	92,026	61	23,831	64	24,523
American	48	13,245	42	15,850	54	18,047	60	14,563	.....	.....	.....	....
Coastwise	38	11,668	66	24,442	42	12,147	63	17,310	23	5,301	37	8,407
Total	225	118,705	244	102,359	232	126,211	251	123,899	84	29,132	101	32,930

	1890.	1889.
Fees	$1,150.66	$1,166.20
Duties on imports	1,641.25	69.34
Tonnage dues	9,399.67	6,205.21
Hospital collections	.....	53.00
Total	12,191.58	7,493.75

	1890.	1889.	1880.
Exports	$999,972.50	$885,467.00	$229,748.17
Imports	1,641.25	214.37	.....

Comparative statement of timber, lumber, etc., shipped by vessels to foreign and coastwise ports.

Articles.	1890.	1889.	1880.
Lumber.....tons	99,776	136,351	17,335
General merchandise.....do	88	13,094	.....
Total	99,894	149,445	17,335

Abstract of proposals for improving Pascagoula River, Mississippi, received and opened January 20, 1890, by Maj. A. N. Damrell, Corps of Engineers.

[Time of commencing and completing work in accordance with specifications.]

No.	Name and address of bidder.	Per cubic yard of dredging.	Price for dam.	
		Cents.		*Plan.*
1	J. H. Gardner, New Orleans, La	27	$1,869	A.
			7,549	B.
2	Alabama Dredging and Jetty Company, Mobile, Ala	17⅛	3,350	A.
3	Geo. C. Fobes & Co., Baltimore, Md	16 2/10	.....	.....
4	John Hogan, Mobile, Ala	.....	4,743	A.

R 6.

IMPROVEMENT OF HARBOR AT BILOXI BAY, MISSISSIPPI.

The examination of this harbor provided for by the third section of the river and harbor act of March 3, 1881, was made during the months of August and September, 1881.

The report is contained in Annual Report of Chief of Engineers, 1882, Appendix K 27.

The examination showed that between the roadstead and the Back Bay are situated a series of mud flats, called Deer Island Flats, about 1¼ miles east of Biloxi, having a present depth of 4 feet.

The improvement understood to be desired was to secure through these flats a channel 8 feet deep. The estimated cost of the work by dredging was $35,000. The act of Congress, August 2, 1882, appropriated $5,000 for the improvement of the roadstead. No project was submitted, the amount appropriated being deemed insufficient for an economical prosecution of the work. Authority was therefore obtained to defer all action until a further appropriation was made.

The act of July 5, 1884, directed that the balance of the money heretofore appropriated for the roadstead be applied to the deepening of the channel from Mississippi Sound to the wharves of Biloxi.

The desired improvement was the deepening of the channel from Mississippi Sound to the wharves of Biloxi from 4½ feet, the least depth at that time, to 8 feet, and the estimated cost was $55,000.

It was not deemed economical or judicious to commence the work with the small amount on hand. Authority was therefore obtained to hold the appropriation until a further one was made to justify a call for bids.

The river and harbor act of August 5, 1886, appropriated $12,500, thus affording with the balance on hand, the sum of $17,488.55 for carrying on the work of improvement.

The plans and estimates heretofore submitted were based upon an examination only (not sufficient for laying out the work properly), the limit of time and money preventing a complete survey, therefore a careful survey of the channel from Mississippi Sound to the wharves of Biloxi, to locate channel to be dredged, was recommended to be made.

This recommendation was approved and $900 from the amount available was allotted for the work.

A project was submitted September 2, 1886, and approved October 16, 1886.

A supplementary project and estimates, based on a survey made in April and May, 1887, were submitted July 8, 1887, and approved July 13, 1887.

The sum of $16,523.64 was available July 1, 1887, for the improvement of this harbor.

Advertisements and specifications for dredging were prepared and published, bids were opened August 17, 1887, a contract was entered into with Geo. C. Fobes & Co., of Baltimore, Md., at 17 cents per cubic yard, and dredging operations were commenced September 12, 1887, and completed March 2, 1888.

Eighty-four thousand six hundred and eighty-six cubic yards of material were removed.

Bids for improving Biloxi Harbor, Mississippi (dredging), were received and opened November 27, 1888, but as prices (15½ cents per cubic yard) were not satisfactory it was deemed best to defer any further action until it was determined, by careful investigation, whether more satisfactory results and a considerable saving might not be effected by the purchase of a proper plant, and the performance of the work by day's labor, especially as it was not believed that commerce would suffer to any extent by the delay. A channel of full projected depth, and wide enough for use with care, having been already obtained, and even if the conclusion was finally to do the work by contract, it was believed that more favorable terms might be obtained when, by another appropriation, the amount available would be increased. The time elapsing would also be of value in determining the permanency of the improvement, concerning which there was considerable doubt. Bids were again solicited and opened January 20, 1890, and contract awarded to Alabama Dredging and Jetty Co., at 14⅜ cents per cubic yard. Work was expected to commence early in July.

The increase of commerce likely to ensue from the completion of this improvement would be impossible to estimate at present, but the benefits of this improvement have been especially felt at Ship Island Anchorage, a much-frequented harbor, 9 miles due south of Biloxi, at which point there arrived and loaded during the fiscal year ending June 30, 1889, no less than 104 ships, representing a total tonnage of 78,253. The dredged channel having made it possible, a line of steamboats is now making two trips a day from Ship Island to Biloxi, thus affording easy and rapid communication between the vessels and their consignees, and enabling captains of vessels to obtain their stores and ship chandlery in a fresher condition and in much less time than formerly, when they were obliged to depend upon Pascagoula or New Orleans. The present condition of the dredged channel is as follows: Eighty-four feet wide and 8 feet deep at mean low water throughout a distance of 5,145 feet or .91 mile, with a width of 126 feet for a distance of 2,150 feet at the lower end, and a width of 124 feet for a distance of 1,030 feet at the upper end.

Before the improvement vessels of more than 5 feet draught could not enter the harbor, while since the improvement vessels of 8 feet draught can come to the wharves of Biloxi.

Money statement.

July 1, 1889, amount available		$18,547.81
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$176.36	
July 1, 1890, amount covered by uncompleted contracts made during fiscal year ending June 30, 1890	16,371.45	
		16,547.81
July 1, 1890, balance available		2,000.00
Amount appropriated by act of September 19, 1890		9,000.00
Amount available for fiscal year ending June 30, 1891		11,000.00
Amount (estimated) required for completion of existing project		10,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		10,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

Articles.	1890.	1889.
Lumber ..... tons..	10,180	9,080
Oysters ..... do...	112,500	56,250
General merchandise. ..... do...	7,140	4,785
Total	129,820	70,115

Canning factories employing 1,800 hands; 200 schooners were engaged in the coastwise trade in 1890, averaging 12 tons. No less than 90 to 100 vessels, representing a total tonnage of 110,000, loaded at Ship Island Anchorage during the fiscal year ending June 30, 1890.

Abstract of proposals for dredging in Biloxi Bay, Mississippi, received and opened January 20, 1890, by Maj. A. N. Damrell, Corps of Engineers.

[Time of commencement and completion, in accordance with specifications.]

No.	Name and address of bidder.	Price per cubic yd.
		Cents.
1	Alabama Dredging and Jetty Company, Mobile, Ala	14⅜
2	Geo. C. Fobes & Co., Baltimore, Md	15 2/16

R 7.

IMPROVEMENT OF PEARL RIVER, MISSISSIPPI, BETWEEN EDINBURGH AND CARTHAGE.

A survey of this part of Pearl River was made under direction of Maj. Amos Stickney, Corps of Engineers, U. S. A., during the month of November, 1883.

The original project for the improvement of this part of the river is to afford a high-water channel from Edinburgh to Carthage, a distance of 24¾ miles, for six or eight months of the year, at an estimated cost of $13,464.

The following appropriations have been made:

Act of July 5, 1884	$2,500
Act of August 5, 1886	2,250
Act of August 11, 1888	5,000
Total	9,750

Under the appropriations, work was commenced on the 17th of November, 1884, suspended January 23, 1885, on account of high water; resumed September 3, 1885, suspended September 30, 1885, on account of lack of funds; resumed November 16, 1886, and suspended December 18, 1886, on account of high water; resumed December 1, 1887, suspended December 27, 1887, on account of high water; resumed June 1, 1889, and suspended December 12, 1889, on account of high water.

The following is a statement of work up to June 30, 1889:

Snags, stumps, and logs removed	9,693
Trees standing in channel removed	368
Overhanging trees removed	2,538
Fallen trees removed	94
Banks cleared of brush, yards	6,491

The work performed during the last fiscal year was as follows:

Snags cut and removed, number of cuts	47,871
Stumps cut and removed	2,261
Logs cut and removed	1,551
Overhanging trees cut and removed	3,965

The entire distance of this part of the river from Edinburgh to Carthage, 24¾ miles, has been fully improved and the project completed. The condition of the river on June 30, 1890, is such as to allow light draught boats to navigate with comparative safety from Edinburgh to Carthage on a 4½ foot rise above ordinary low water.

Owing to caving in of banks and shifting of the channel the improvements so far made will not be permanent, and it is estimated that an annual expenditure of $500 will be required to maintain the river in the condition contemplated by the plan of improvement.

The reduction and saving in railroad freights as well as the reduced rates of insurance on freights, both up and down stream, due to river competition, are considerable.

Only one steam-boat, of 110 tons burden, has been employed on the river during the last fiscal year, carrying about 600 tons general merchandise, grain, fertilizers, etc., up stream. Approximate value, $50,000. Two hundred tons cotton, country produce, etc., were carried down stream. Approximate value, $40,000.

Money statement.

July 1, 1889, amount available	$4,494.13
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	3,864.60
July 1, 1890, balance available	629.53
Amount appropriated by act of September 19, 1890	5,000.00
Amount available for fiscal year ending June 30, 1891	5,629.53
Amount (estimated) required for preservation of improvement	500.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	500.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

R 8.

IMPROVEMENT OF PEARL RIVER, MISSISSIPPI, FROM JACKSON TO CARTHAGE.

An examination of this part of the river was made under direction of Capt. C. W. Howell, Corps of Engineers, in 1879.

The original project for the improvement of this part of the river consisted in the removal of snags, logs, overhanging trees, etc., and was to afford a clear channel of navigable width, 5 feet deep at a low stage of the river from Jackson to Carthage, a distance of 105 miles, at an estimated cost of $21,000.

An examination made in January, 1887, showed that a clear 5-foot channel at low water was not practicable by the method proposed on this section of the river, but that a 2-foot channel at low water could be obtained in that manner and was all that the present commerce of the river required.

Upon that examination the original estimate of the cost of the improvement was increased $29,000. (See Annual Report, 1886–'87, Q 9, page 1336.)

The following appropriations have been made:

By act of—	
March 3, 1879	$6,000
June 14, 1880	7,500
March 3, 1881	2,500
August 2, 1882	2,500
August 6, 1886	2,250
August 11, 1888	2,500
Total	23,250

Under the appropriations, work was commenced by contract November 20, 1879; the work, however, not proving satisfactory, the contracts were annulled September 22, 1882, and the work was continued by hired labor during the low-water seasons of 1883 and 1884; suspended in January, 1885, on account of lack of funds, resumed January 1, 1887; suspended January 29, 1887, on account of high water, resumed August 1, 1887; suspended November 30, 1887, on account of lack of funds, resumed in September, 1888, and suspended December 31, 1888, on account of high water.

The following is a statement of work up to June 30, 1889:

Snags cut and removed	22,582
Stumps cut and removed	930
Sunken logs cut and removed	4,020
Overhanging trees cut and removed	372

No work was done on this section of the river during the last fiscal year.

Eighty-nine miles of river from Carthage down have been fully improved, and 16 miles, down to Jackson, have been partially improved.

The condition of the river on June 30, 1890, is such as to allow light-draught boats to navigate with comparative safety on a 3-foot rise above ordinary low water from Carthage down 89 miles, and the remaining distance down to Jackson, 16 miles, on a 4-foot rise.

Owing to a caving in of banks and shifting of the channel the improvements so far made and contemplated will not be permanent; an annual expenditure of $2,400 would be required, after completion of the

improvement, to maintain the river in the condition contemplated by the plan of improvement.

The reduction and saving in railroad freights as well as the reduced rates of insurance on freights, both up and down stream, due to river competition, are considerable. It is proposed to apply any appropriation that may be made for the fiscal year ending June 30, 1892, to completing 16 miles above Jackson and to re-working the 89 miles below Carthage.

The following are the vessels that have navigated this portion of the river during the last fiscal year: 1 stern-wheel steam-boat, 1 propeller, 5 flat-boats; total tonnage, 325.

Fourteen hundred tons of general merchandise, grain, fertilizers, machinery, etc., were carried up-stream. Approximate value, $98,000. Twelve thousand two hundred and fifty tons of cotton, staves, lumber, shingles, sawlogs, fowl, produce, etc., were transported down-stream. Approximate value, $200,000.

Money statement.

July 1, 1889, amount available	$293.27
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	190.00
July 1, 1890, balance available	103.27
Amount appropriated by act of September, 19, 1890	3,000.00
Amount available for fiscal year ending June 30, 1891	3,103.27
Amount (estimated) required for completion of existing project	23,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	23,500.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

R 9.

IMPROVEMENT OF PEARL RIVER, MISSISSIPPI, BELOW JACKSON.

The original project for improving this section of the river was adopted in 1880, the object being to obtain a navigable channel 5 feet deep at low water from Jackson down to the mouth by the removal of snags, stumps, roots, sunken logs and trees, and the clearing of banks of overhanging trees, at an estimated cost of $95,940, based upon the report of a survey made under direction of Capt. C. W. Howell, Corps of Engineers, during March and April, 1879.

Upon an examination made in December, 1884, it was found that a 5-foot clear channel at low water was not practicable by the method proposed, but that a 2-foot channel at low water could be obtained in that manner, and was all that the present commerce of the river required.

Upon that examination the original estimate of the cost of the improvement was increased $50,000. (See Annual Report 1885–'86, Q 9, page 1367.)

In addition to the improvement of the river proper, the increased lumber trade of the mills situated on the river demands the deepening of the bar at the mouth of East Pearl River down to 12 feet, a rough estimate of the cost of dredging, which is $20,000.

No work has as yet been done at this bar.

The following appropriations have been made:

By act of—	
June 14, 1880	$30,000
March 3, 1881	25,000
August 2, 1882	15,000
July 5, 1884	10,000
August 5, 1886	13,125
August 11, 1888	15,000
Total	108,125

Under these appropriations work was commenced by contract in December, 1880, working from Jackson down, 295 miles of river, were partially improved.

August 23, 1882, contract work was completed and accepted.

In November, 1882, work on the improvement by hired labor was commenced and was suspended in November, 1883; resumed June, 1884, suspended September 1, 1884, on account of high water; resumed December 1, 1884, suspended June 30, 1885, on account of lack of funds; resumed in September, 1885, suspended March 30, 1886, on account of lack of funds.

Work was again resumed September 5, 1886, suspended November 22, 1887, on account of lack of funds; resumed October 20, 1888, and suspended October 23, 1889, on account of lack of funds.

The following is a statement of work performed from 1884 up to the 30th of June, 1889:

Snags removed		5,359
Roots removed		6,808
Sunken logs removed		4,839
Sunken trees removed		1,922
Stumps removed and blasted		2,066
Knees cut and removed		87
Standing trees cut and removed		1,454
Overhanging trees removed and cut		18,364
Standing trees deadened		2,011
Sand and clay removed	cubic yards	11,739½
Cane removed	running yards	9,422
Piles driven for jetties		256
Willows planted for jetties	cords	666
Willows cut, made into mattresses, and sunk	do	618½
Trees felled, cut in lengths, and sunk for jetties		1,531
Sunken logs and trees pulled and sunk for jetties		116
Clay dug out, wheeled and transported, and filled in in jetties	cubic yards	3,220

The work performed during the last fiscal year was as follows:

Snags removed	1,865
Stumps removed	163
Sunken trees removed	855
Sunken logs removed	165
Overhanging trees removed	1,777
Trees deadened	758

Fifty-one miles of river, from the mouth at the Rigolets to Wakiah Bluff, have been fully improved. Fifty-five miles of river from Wakiah Bluff to Wheats Field have been improved for 100-foot wide channel, and 50 miles of river from Wheats Field to Columbia have been partially improved. From Columbia to Jackson the river had been partially improved by contract; no work has been done on that section since, and it remains in about the same condition.

The condition of this part of the river on June 30, 1890, is such as to allow light-draught boats to navigate from the mouth at the Rigolets, La., to Wheats Field, Mississippi, 106 miles, all the year around; from

Wheats Field to Columbia, Miss., 50 miles on a 6-foot rise, and from Columbia to Jackson, Miss., only on a 7-foot rise, and then it is dangerous.

The benefits that are derived by the improvement of this section of the river are greater security to navigation between New Orleans, La., and Columbia, Miss., and other towns and settlements situated on the river, and reduced rates of freight and insurance on merchandise and produce. Large tracts of rich and valuable bottom lands have been reclaimed by the improvement and are now being cultivated. It is proposed to apply any appropriation that may be made for the fiscal year ending June 30, 1892, to continuing the improvement of the river for a 2-foot clear channel, at low water, between Columbia and Jackson.

It is also proposed to apply any appropriation that may be made for the fiscal year ending June 30, 1892, for deepening the bar at the mouth of East Pearl River to dredging a channel 12 feet deep at mean low water as far as the funds available will permit.

Owing to caving in of banks after freshets, as also to the shifting of the channel, the improvements, so far made and contemplated, will not be permanent. An annual appropriation of $5,000 would be sufficient to maintain the river in the condition contemplated by the plan of improvement.

Money statement.

July 1, 1889, amount available	$7,770.04
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	3,748.59
July 1, 1890, balance available	4,021.45
Amount appropriated by act of September 19, 1890	20,000.00
Amount available for fiscal year ending June 30, 1891	24,021.45
Amount (estimated) required for completion of existing project	35,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	35,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

R 10.

EXAMINATION AND SURVEY OF WARRIOR RIVER, ALABAMA, FROM TUSCALOOSA TO DEMOPOLIS; TOMBIGBEE RIVER FROM ITS MOUTH UP TO VIENNA, AND TOMBIGBEE RIVER BETWEEN VIENNA AND COTTON GIN.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., January 23, 1890.

SIR: I have the honor to submit herewith a copy of the report, dated December 24, 1889, upon the survey of Warrior River, Alabama, from Tuscaloosa to Demopolis, for deepening and widening the channel with a view to easy transportation of coal, and Tombigbee River, between Vienna and Cotton Gin, with a view of obtaining continuous navigation, made under the direction of Maj. A. N. Damrell Corps of Engineers, to comply with the requirements of the river and habor act of August 11, 1888. In view of the fact that the rivers referred to are so connected as to form a system of continuous navigation, it was deemed advisable to include them in the same report.

Copies of the reports upon the preliminary examinations of the localities are also herewith.

The main water route from the Gulf of Mexico into the interior of Mississippi and western Alabama is by way of the Mobile Bay, up the Mobile River to the junction of the Alabama and Tombigbee rivers, thence up the Tombigbee to its junction with the Warrior near Demopolis, thence up the Warrior to Tuscaloosa, Ala., and thence into the mineral field above Tuscaloosa, or by the Tombigbee into Mississippi from Demopolis to Vienna, and head of navigation of that stream.

(1) The improvement of the Warrior River above Tuscaloosa is now being prosecuted by the United States under a project providing for a depth of 6 feet at low water, by means of locks and dams, and it is proposed to obtain this depth in the river from Tuscaloosa to its mouth near Demopolis. The condition of this portion of the Warrior, however, not being favorable for locks and dams, a system of dams with pneumatic gates is proposed at an estimated cost of $577,000, and annual cost of maintenance $15,000.

(2) From the mouth of Tombigbee River to Demopolis it is believed that a 6-foot depth can be obtained by snagging operations, bank revetment, etc., and the construction of three locks and dams at an estimated cost of $508,898.

(3) Continuous navigation of 6-foot depth for the Tombigbee River between Demopolis and Vienna is proposed to be secured by the construction of dams with pneumatic gates at an estimated cost of $389,600, and $13,500 for annual maintenance.

(4) From Vienna to Columbus, or Cotton Gin Port, the same system of improvement is proposed at an estimated cost of $389,800, and $15,000 for annual maintenance.

The total estimated cost of improvement for Tombigbee and Warrior rivers is $1,865,298, and the estimate for annual maintenance is $43,500.

It will be seen that estimates are submitted for the Lower Tombigbee River in this connection in order that Congress may have information in regard to the improvement of the whole system of navigation on the Warrior and Tombigbee.

Major Damrell has been instructed to transmit to this office drawings of dams and pneumatic gates proposed for these rivers, and these drawings, when received, will be submitted.

Very respectfully, your obedient servant,

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

Hon. REDFIELD PROCTOR,
Secretary of War.

PRELIMINARY EXAMINATION OF WARRIOR RIVER, ALABAMA, FROM TUSCALOOSA TO DEMOPOLIS, FOR DEEPENING AND WIDENING THE CHANNEL WITH A VIEW OF THE EASY TRANSPORTATION OF COAL.

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., February 14, 1889.

SIR: I have the honor of submitting the following report on the preliminary examination of the "Warrior River from Tuscaloosa to Demopolis for deepening and widening the channel with the view of the easy transportation of coal."

This section of the river is in my opinion worthy of improvement as stated above.

Work under a project to obtain a channel with a minimum depth of 4 feet and a minimum width of 80 feet has been in progress since 1875, and was intended for the relief of the commerce at that time, the transportation of cotton and plantation supplies. The reduction in freight charges due to competition between river and rail has been estimated at about $50,000 per annum on the present business.

This year work was commenced in the river above Tuscaloosa for the development of a new kind of commerce, the transportation of coal, requiring a greater depth (6 feet) and width of channel.

This compels a change in the project for the lower river.

With an improved water route from the Warrior coal fields to the Gulf of Mexico, having a minimum channel depth of 6 feet, the coal transportation by it should soon reach such an amount that the annual saving to the consumers on account of the reduction in cost from present prices, due to the cheap river freight and competition with railroad, would equal the sum required for the improvement.

The cost of the improvement of this section of the river would not exceed $1,000,000.

No estimate is submitted of the amount needed to make the survey, report, and project, for the reason that the greater portion of the survey has been made, and it can be completed in connection with the work of improvement at present in progress.

Very respectfully, your obedient servant,

A. N. DAMRELL,
Major, Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

PRELIMINARY EXAMINATION OF TOMBIGBEE RIVER, ALABAMA AND MISSISSIPPI, BETWEEN VIENNA AND COTTON GIN, WITH A VIEW OF OBTAINING CONTINUOUS NAVIGATION.

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., February 16, 1889.

SIR: I have the honor of submitting the following report of preliminary examination of "Tombigbee River between Vienna and Cotton Gin, with a view of obtaining continuous navigation."

The following report made in 1887, and contained in the Annual Report of the Chief of Engineers for 1888, is repeated:

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., February 9, 1887.

SIR: I have the honor of submitting the following report concerning the preliminary examination of "the Tombigbee River to ascertain what improvement is necessary to make said river continuously navigable from Vienna, Ala., to Walker's Bridge, Miss.," provided for by river and harbor act of August 5, 1886.

This entire section of the river has already been carefully examined, and reports thereon are contained in annual reports of the Chief of Engineers for 1871, for that part of the river from the mouth up to Columbus, Miss., 1873, for that part from Columbus up to Fulton, and a report of that part from Fulton up to Walker's Bridge was submitted November 4, 1881.

From these examinations it was believed that the only improvement possible was by the removal of snags and overhanging trees to obtain a high-water channel from Walker's Bridge, 5 miles below Warren's Mills, down to the mouth. This has been done from Fulton down.

In the course of the above improvement under appropriations made by Congress for different sections of the river since that time the opinion was formed in 1879 that a still further improvement of that portion of the river from Columbus down to the mouth could be made so as to obtain a low-water channel of 3 feet depth from Columbus down to Demopolis, and of 4 feet from Demopolis down to the mouth. A considerable portion of this work has already been accomplished.

The only other improvement now possible is by the slackwater system from Columbus down, and while that might not be warranted by the present commerce the movement of coal from the Warrior fields by river in the future may make it of sufficient importance to examine into the feasibility of the method, in which case a survey could be made during the progress of the present improvement.

The only section of the river for which no appropriation has yet been made and on which, therefore, no work has been done, is that portion from Warren's Mills down to Fulton. The improvement of that portion from Warren's Mills down to Walker's Bridge for steam-boat navigation is not practicable on account of the narrowness of the stream and abrupt banks. From Warren's Mills down to Fulton the river can be improved by the removal of snags, logs, and overhanging trees at an estimated cost of about $11,000, and would result in a saving to the planters on this portion of the river in freights on cotton and return supplies of probably about $6,000 per annum.

Cotton Gin is between Walker's Bridge and Columbus and about 60 miles above Columbus.

The survey referred to in the above report has been nearly finished and can be completed during the next low-water season, in connection with the present improvement. No estimate for survey is, therefore, submitted.

Very respectfully, your obedient servant,

A. N. DAMRELL,
Major, Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

SURVEY OF WARRIOR RIVER, ALABAMA, FROM TUSCALOOSA TO DEMOPOLIS; TOMBIGBEE RIVER FROM ITS MOUTH UP TO VIENNA, AND TOMBIGBEE RIVER BETWEEN VIENNA AND COTTON GIN.

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., December 24, 1889.

SIR: I have the honor of submitting the following report upon the survey of the "Warrior River from Tuscaloosa to Demopolis for deepening and widening the channel with a view of the easy transportation of coal," and the "Tombigbee River between Vienna and Cotton Gin, with a view of obtaining continuous navigation," provided for by the river and harbor act of August 11, 1888, and of the Tombigbee from its mouth up to Vienna, made in connection with the improvement of same.

The main water-route from the Gulf of Mexico up into the interior of Mississippi and Alabama under charge of this office is by way of Mobile Bay, the channel in which is now being deepened to 23 feet, up to the city of Mobile where the ocean and river craft meet, up the Mobile River, which now has a least depth of 13 feet, and can be given a depth of 30 feet, to the junction of the Alabama and Tombigbee, a distance of about 47 miles, thence up the Tombigbee, a distance of 191 miles, to the junction of the Tombigbee and Warrior rivers, near Demopolis, thence up the Warrior River into Alabama, 132 miles, to Tuscaloosa, and from there up into the mineral field above Tuscaloosa, or by the Tombigbee River into Mississippi from Demopolis up to Vienna, where the Sipsey joins, a distance of 91 miles, thence up the same stream to Columbus,

a distance of 65 miles, thence up to the head of navigation. The rivers being thus connected, it has been deemed proper to report upon them together so that a systematic improvement may be made, if one is entered upon.

The Government is now improving the Warrior above Tuscaloosa for craft of 6 feet draught at low water, and there is more than that depth in the Mobile River below, both ends of the line open or to be open, with the river between with not channel depth equal or sufficient for the present commerce; for although the Government has been engaged in the improvement of this portion for a number of years and is now, the project adopted, under different conditions, contemplated only from 3 to 4 feet depth, and even if carried to a successful completion would not be satisfactory for the reasons that the depth is not sufficient and the bars formed by high water in the low-water chutes require some time in washing away when the river falls.

The 6-foot depth above Tuscaloosa should therefore be obtained in the river below and by some system not open to the objection above specified.

It is believed that this can be accomplished from the mouth of the Tombigbee up to Demopolis by the following works at a cost estimated as follows:

Snagging and tree-cutting	$20,000
Bank revetment	45,000
Dredging a channel at Harwell's Bar	2,760
Three locks and dams	381,138
Plant and tools	60,000
Total	508,898

The locks to be similar to those on the Warrior above Tuscaloosa as regards dimensions and general construction, one to be located at McGrew's Shoals (rock), one at Naheola (rock) 76 miles above, and the third near Black's Bluff (rock), 24 miles above No. 2, which will give backwater up to the Warrior and Tombigbee, about 13 miles above Demopolis.

The fall in the river was found to be 28.37 feet from Demopolis to Mobile, and maximum fall per mile 0.49 foot. The discharge at Demopolis 1,500 cubic feet per second, and 77 miles below 1,800 cubic feet per second. Conditions for construction of locks at the localities mentioned are considered favorable.

From Demopolis to Tuscaloosa the conditions are not favorable for the construction of locks and dams and a system of dams with pneumatic gates is proposed. The work is estimated to cost as follows:

Snagging and tree-cutting	$25,000
Bank revetment	27,000
Bar improvement	126,000
Dams and pneumatic gates	399,000
Total	577,000

Annual cost of maintenance, $15,000.

Details of dam and gates are to be furnished hereafter. The fall was found to be for the entire distance of 132 miles 60.20 feet.

The low-water discharge at Tuscaloosa 400 cubic feet per second.

Continuous navigation proposed for the Tombigbee River above Vienna to Columbus or Cotton Gin Port will for the same reasons given in connection with the Warrior and Tombigbee rivers below Demopolis require the improvement of the Tombigbee between Demopolis and Vienna, and therefore 6 feet depth is proposed for the river from Demopolis up

to Columbus, which it is believed can be accomplished by the same means proposed for the Warrior below Tuscaloosa, at an estimated cost as follows:

From Demopolis up to Vienna:	
Dam with pneumatic gates	$370,600
Additional bank revetment required	9,000
Cutting off rock point above Jones Bluff Bridge	2,000
Snagging and tree-cutting	8,000
	389,600

The fall was found to be in the 91 miles 58.74 feet and the discharge at low water, 1 mile below Vienna, 700 cubic feet per second, and at the mouth 900 cubic feet per second.

Thirteen thousand five hundred dollars would be required for maintenance yearly.

From Vienna up to Columbus the same system of improvement is proposed at an estimated cost as follows:

Dam and gates	$348,800
Bank revetment	18,000
Snagging	9,000
Bar improvement by contraction work	14,000
	389,800

For maintenance yearly, $15,000.

The fall was found to be for the distance, 65 miles, 49 feet.

Low-water discharge, 500 cubic feet per second at Columbus, and 600 cubic feet per second at Vienna.

The survey was not carried above Columbus, as it was believed that it was not worthy of improvement for continuous navigation at present.

In connection with the surveys thirty-one sheets of maps are now completed, and the remainder are in hand and will be completed as soon as possible.

In conclusion, I would state that in my opinion these improvements, if undertaken, should be carried on as follows:

The Tombigbee, from its mouth up to Demopolis, should be improved as rapidly as possible, it being the most important, as carrying the combined commerce of the Warrior and Tombigbee above Columbus, and $500,000 could be advantageously expended during the next fiscal year in addition to the amount specified in the annual report.

The Warrior River from Demopolis to Tuscaloosa comes next in importance, owing to the large amount of coal to be transported in the near future, in addition to the ordinary commerce of plantation products and supplies, and the snagging and bank revetment, estimated to cost $52,000, should be done as soon as possible.

One hundred and twenty-five thousand dollars could be advantageously expended during the next fiscal year, in addition to the amount specified in the annual report, if the plan for dams and pneumatic gates is approved.

The Tombigbee from Demopolis to Vienna, and from Vienna up to Columbus, comes next in importance, and, as on the Warrior, the snagging and bank revetment should be done immediately, and $175,000 could be advantageously expended in addition to the amount specified in the annual report for the next fiscal year, if the plan for dams and gates proposed proves a proper one.

Detailed surveys and plans for locks and dams on the Tombigbee River from mouth up to Demopolis can be made and submitted for approval, should the general plan be approved.

The commercial statistics for the rivers being given in the annual report of improvement of same are not repeated here, but it should be understood that the importance of the work is not determined so much by present commerce as by the expected increase from mineral shipments from the Warrior fields.

Respectfully submitted.

A. N. DAMRELL,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

R 11.

PRELIMINARY EXAMINATION OF SIPSEY RIVER, ALABAMA, FROM THE TOMBIGBEE RIVER AT VIENNA TO TEXAS, WITH A VIEW OF EASY TRANSPORTATION OF COAL.

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., February 14, 1889.

SIR: I have the honor of submitting the following report of the preliminary examination of the "Sipsey River from the Tombigbee River at Vienna to Texas, with a view of easy transportation of coal."

An examination of the river between the points mentioned was made in 1879, results of which are stated in the Annual Report of the Chief of Engineers for 1881.

In my opinion the river is worthy of improvement for high-water navigation.

So improved, the river would furnish cheap transportation for at least 10,000 bales of cotton and other produce and supplies of equal value and a water-route less than 500 miles for the transportation of coal from the Warrior fields to Mobile during about five months of the year. Coal and cotton have both been carried in barges to Mobile by the river in its unimproved condition.

The cost of the improvement would not exceed $400,000.

No survey is needed, but an examination of the river should be made when the river is about 6 feet above low water, the previous one having been made during extreme low water.

There is money available for this examination of the amount allotted for examinations.

Very respectfully, your obedient servant,

A. N. DAMRELL,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

SURVEY OF SIPSEY RIVER, ALABAMA, FROM THE TOMBIGBEE RIVER AT VIENNA TO TEXAS, WITH A VIEW OF EASY TRANSPORTATION OF COAL.

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., February 8, 1890.

SIR: I have the honor of submitting the following report of the final examination of the "Sipsey River from the Tombigbee River at Vienna to Texas, with a view of easy transportation of coal."

An examination of the river between the points mentioned was made in 1879, report of which is contained in the Annual Report of the Chief of Engineers for 1881, and was printed in Senate Ex. Doc. No. 42, Forty-sixth Congress, third session.

This examination was made at an unusually low stage of low water, and while the river was choked up with an accumulation of drift, caused by felling timber into the river in an attempt to improve it under State authority.

The length of the river to be improved then was given as approximately 145 miles, and the estimated cost of improvement for high-water navigation $145,000, and the length of season for boating as eight months.

The final examination made in January and February, 1890, was made at a stage $3\frac{1}{2}$ to 5 feet above ordinary low water.

It was found that the river had cleared itself of the greater part of the drift accumulation above mentioned and made a much better showing at this stage of water than at the previous examination. The character of the river is shown in the following table:

Section of river.	Length of section.	Minimum and maximum width of channel.	Depth at extreme low water.	Depth at extreme high water.	Height of banks.	Character of bed.	Character of banks.	Character of obstructions.
	Miles.	*Feet.*	*Inches.*	*Feet.*	*Feet.*			
Texas to Newton's Mill	35	60 to 80	6	23 to 12	6 to 8	(1)	(2)	
Newton's Mill to 40 miles of mouth	100	40 to 100	12	12	6 to 10	(3)	(4)	(5)
Forty miles to mouth	40	60 to 80	12	25	10 to 30	(3)	(6)	(7)

[1] Coal, rock, gravel, and sand.
[2] Clay, rock, and alluvial.
[3] Gravel, sand, and mud.
[4] Clay and alluvial.
[5] Fish traps, mill-dams.
[6] Blue lime rock, clay, and alluvial.
[7] Islands, bridges, logs, and trees.

NOTE.—There is at present no commerce, but the country along the river is rich in coal and timber, and much of it is very fertile. Minimum width of river when navigable, 80 feet; fall about 6 inches per mile. Water falls slowly after a rise, the bottoms being overflowed on a 10-foot rise. Discharge of the river at low water about 117 cubic feet per second.

Texas is situated on the east fork of Sipsey (called New River). The obstructions mentioned in the foregoing table are three mill-dams: First, Newton's, 35 miles below Texas; second, Lindsey's, a few miles below, both in a dilapidated condition; third, Horton's, or Sipsey, down towards the mouth, in bad condition. This dam, 7 feet high, is the greatest obstruction to navigation at present.

Two railroad bridges: First on K. C. R. R., 3 miles below Texas, 21 feet above low water, 70 feet between piers; second, G. P. R. R., east of Fayette Court-House, 16 feet above low water, 70 feet between piers; twelve highway bridges, wooden structures distributed along the river from 6 to 10 miles apart, and from about 12 to 18 feet above low water; twelve fish traps, made by driving piles and wattling brush between them, all weak structures and covered by a slight rise; snags and overhanging trees. Coal crops out 2 miles above Texas in a 36-inch vein, and is found in the bed of the river in four different places in the distance of 14 miles in veins 18 inches thick, and in one place it forms the bed of the river for over a mile, with 6 inches of water on it at low water.

The only improvement that seems to be possible is the removal of obstructions above mentioned, so as to give navigation for about four

months in the year, and would cost not exceeding $500 per mile, or a total of $100,000, including plant required, not considering the bridges.

A stiff raft 148 feet long and 20 feet wide has been carried out of the river in its present condition; also three barges 78 feet long by 18 feet beam, and three keel-boats 70 feet long by 13 feet beam, loaded with coal, cotton, and staves.

With an improved river there would be a saving in freight on cotton and plantation supplies of not less than $15,000 per year, and there would be soon a large coal trade developed.

Respectfully submitted.

A. N. DAMRELL,
Major, Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

APPENDIX S.

INSPECTION OF THE IMPROVEMENT AT THE SOUTH PASS OF THE MISSISSIPPI RIVER.

REPORT OF CAPTAIN W. L. FISK, CORPS OF ENGINEERS, INSPECTING OFFICER, FOR THE FISCAL YEAR ENDING JUNE 30, 1890.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., July 1, 1890.

GENERAL: I have the honor to submit my report for the fiscal year ending June 30, 1890, upon the improvement of South Pass of the Mississippi River.

The accompanying charts were prepared as usual by Mr. C. Donavan, who has been for so many years the assistant engineer in local charge of the surveys and examinations. His report in detail of the operations of the past year is herewith, and is so complete that there is nothing more of importance to be said.

The legal channel has been maintained throughout the year, except during the first five days in October, when the central depth between the extreme ends of the jetties was only 29.6 feet, instead of the required 30 feet.

The direct channel to sea from the ends of the jetties had a least depth during the year of 28.3 feet, while that turning to the eastward from the ends of the jetties had a least depth of 31.5 feet, with a least width 130 feet between the 30 feet curves.

The least depth between the Head of the Passes and the Gulf during the year was 27 feet, which prevailed but a short time.

In December last a steam-ship drawing 27 feet went out through the jetties in a dense fog without the slightest trouble.

In April last a steam-ship was aground in the upper part of the pass, but it was because she was not in the channel, where there was plenty of water.

The demurrer filed in the cases of the pilots and masters indicted for violation of the "rules regulating the navigation of South Pass," and which at the date of the last annual report was held under advisement, was overruled and the ualidity of the rules established. One pilot was brought to trial, but was acquitted by the jury, a result directly attributable, in my opinion, to an almost entire lack of effort to convict by the district attorney.

ESTIMATE OF FUNDS REQUIRED FOR EXAMINATIONS AND SURVEYS AT SOUTH PASS OF THE MISSISSIPPI RIVER DURING THE FISCAL YEAR ENDING JUNE 30, 1892.

1 assistant engineer	$2,700
1 recorder	1,200
1 steam engineer	1,200
1 water-level observer	120
6 seamen	3,370
Rent of office	180
Rent of assistant engineer's quarters	240
Mileage and traveling expenses	200
Fuel for launch and office	350
Repairs to launch and boats	1,000
Supplies for launch and office	500
Contingencies	2,000
Total	13,060

Money statement.

July 1, 1889, amount available	$11,042.27
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	10,000.00
July 1, 1890, balance available	1,042.27
Amount appropriated by act of August 11, 1888	10,000.00
Amount available for fiscal year ending June 30, 1891	11,042.27

Very respectfully, your obedient servant,

W. L. FISK,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. C. DONOVAN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Port Eads, La., July 1, 1890.

SIR: I have the honor to submit my report for the year ending June 30, 1890, upon the condition of the works carried on by James F. How and Estill McHenry, of St. Louis, Mo., for the improvement of South Pass, of the Mississippi River; also the amount and character of the work done during the year to maintain said works and the channel created by them. The results of examinations and surveys made during the year are added to and compared with those deduced in former years, and are so tabulated or represented graphically as to furnish a history of the changes which have taken place at the Head of the Passes, throughout South Pass, and in the Gulf of Mexico, from year to year, and in some instances from month to month, during the past fifteen years.

The following charts accompany this report:

No. 1. Chart of the channel from South Pass light-house, through the jetties, to deep water in the Gulf.

No. 2. Chart of a part of the Gulf of Mexico, showing depths out to that of 100 fe

No. 3. Chart of a part of South Pass, from South Pass light-house to Grand Bayo

No. 4. Chart of a part of South Pass, from Grand Bayou to the Head of the Pass.

No. 5. Chart of the Head of the Passes.

No. 6. Plans and comparative profiles of South Pass.

No. 7. Results of tidal, sediment, and velocity observations.

No. 8. Diagrams showing changes in the Gulf for each year from 1876 to 1890.

AT THE HEAD OF THE PASSES.

The west T-head or west jetty at this locality had so far deteriorated that it was from 3 to 15 feet below the plane of average flood tide. During the year it has been substantially built up so that it is now from 2 to 4 feet above that plane.

This additional work extends over a distance of 980 feet, and consists of three rows of piles, except for a distance of 190 feet, where there are but two rows, 8 feet apart, the piles in each row being 6 feet apart, and are driven through the mattresses of which this work was originally built. On the outside of the two outer rows of piles 12 by 12 inch timbers are bolted, and these are connected at irregular intervals by ties of the same material, to prevent the piles from spreading when the willows which are placed loosely between them are forced down. The willows are compressed and kept in place by sacks filled with earth taken from the banks of the pass, and some is put on loosely after the work is well above the surface of the water.

The following materials were used in this work: Four hundred and eleven piles, 2,606 linear feet of 12 by 12 inch timber, 252 screw-bolts of $\frac{7}{8}$ inch iron 2 feet long, 143 drift-bolts of $\frac{3}{4}$ inch iron $1\frac{1}{2}$ feet long, 2,371 cords of willows, 39 cubic yards and 452 sacks of earth.

One hundred and forty-six cords of willows and 30 cubic yards of stone were added to upper dam. Fifteen feet of the west end of this work washed out during the year, but the remainder is in good condition.

MATTRESS SILLS ACROSS SOUTHWEST AND NORTHEAST PASSES.

These structures have remained practically unchanged during the year, and, therefore there is nothing to add to my report relative to them.

IN SOUTH PASS.

In Goat Island Reach, Wing-dams 2 and 5 were improved by the addition of 117 cords of willows and 34 sacks of earth. Later, however, the former was undermined and very much damaged.

With the exception of No. 9, which is in good condition, the others are more or less wrecked and will require rebuilding in case they should be needed again.

In Grand Bayou Reach, Dams 6, 7, 8, 10, 11, and 12 received 244 cords of willows, which were weighted with earth taken from the adjacent shore, some of which was contained in 28 sacks. These structures are in good condition, but the other and older ones at this locality are of no practical value.

The locations of the dams in these two reaches are shown on Charts 3 and 4.

At four localities along the banks of the pass 4 cords of willows and 64 cubic yards of stone were placed to arrest the tendency to the formation of small bayous from the pass into the bays.

AT THE MOUTH OF SOUTH PASS.

East jetty.—The work of rebuilding the concrete wall on this jetty, and the addition of crib-work to another portion of it, is fully described in my last annual report. The former work was practically completed during the month of September, after which time it was plastered to give it an even surface.

I invite attention to Chart No. 1 for information relative to this work, as it is given there in more concise form and will be better understood than by any descriptive record.

At the end of the last fiscal year there were 2,177 feet of this wall in place, and to complete it, 2,666 feet were built; over this distance 799 feet were of the larger size blocks, 733 feet of the smaller size, 812 feet of parapet replaced on the original foundation blocks, and 322 feet where an addition was made to the parapet.

Following downward from a point 6,205 feet below East Point, at which the concrete work commences, this work as it exists at present is as follows:

650 feet of new wall of smaller size blocks.
169 feet of old wall as originally built.
31 feet of new wall of smaller size blocks.
135 feet of old wall as originally built.
292 feet of new wall of smaller size blocks
2,736 feet of new wall of larger size blocks.
519 feet of new parapet on old foundation blocks.
322 feet where an addition was made to old parapet.
195 feet of new parapet on old foundation blocks.
366 feet of old wall as originally built.
98 feet of new parapet on old foundation blocks.
46 feet of old wall as originally built.

At a point 8,560 feet below East Point the foundation was undermined and the wall settled about 3 feet at one point. For a distance of 35 feet on either side of this point the settlement varies so that a gradual slope is formed to the point of greatest depression. The wall is simply cracked in places, and remains firmly in place.

The foundation at this point has been protected by placing a quantity of stone on the sea-side of the wall, and this will be done till the foundation is secure.

During the six months ending March 31 the average subsidence of the new concrete works, not including the point of greatest subsidence, was .05 of a foot, being greatest where the wall rests upon a new foundation, as would be expected.

Cribs.—The work of raising the surface of the jetty above a point 6,205 feet below East Point, by placing cribs upon the original mattress work, was continued when the conditions were favorable.

Thirteen of them were placed over a distance of 730 feet, thus bringing this work to a point 5,126 feet below East Point. Twelve of them are each 56 feet long, and one 58 feet; they are generally 10 feet wide and 4 feet high, and when filled with stone are from 2 to 3 feet above average flood tide.

The following materials were used in the construction of the east jetty during the year: One hundred and thirty-five cords of willows, 1,538 cubic yards of stone, 1,671 cubic yards of concrete, 2,028 yards burlap, 1,314 sacks, 11,194 linear feet of 12 by 12 inch timber, 2,016 feet, B. M., 2 by 12-inch lumber, 1,750 drift-bolts, and 208 screw-bolts.

WEST JETTY.

No work has been required on this jetty for several years; it is in good condition, and, with the continued rapid growth of the land formation, it will in a few years be completely buried.

INNER EAST JETTY.

Special attention has been given to this work for a distance of 1,300 feet below Dam 26, where, on account of the condition of the main jetty, it was exposed to heavy seas. It has also been extended above Dam 26 a distance of 335 feet, and will be still further extended. This became necessary on account of the rapid recession of the reef to the eastward of the main jetty, whereby that jetty was exposed, and not sufficiently high to prevent the loss of a volume of water from the channel or to prevent sand from being driven into the channel during severe storms, both of which objects the inner jetty accomplishes.

This reef receded 200 feet during the year.

This work is in good condition throughout, and is from 3 to 5 feet above average flood tide.

Two thousand nine hundred and fifty-two cords of willows, 1,043 cubic yards of stone, and 117 piles, were used in its construction and maintenance during the year.

INNER WEST JETTY.

This construction required but little attention during the year; 403 cords of willows were added to it. It is in good condition and from 2 to 4 feet above average flood tide.

WING-DAMS.

During the year three wing-dams were built on the west side of the channel, and from 2,830 to 3,280 feet below East Point. They are numbered 35, 36, and 37 on Chart No. 1, and are respectively 135, 73, and 181 feet long. They are of the usual construction, consisting of two or three rows of piles from 6 to 10 feet apart, between which willows are placed and weighted with stone or earth. At the shore ends, where the water is too shoal to permit of piles being driven, the willows are confined between rows of stakes.

Willows and ballast material were added to Dams 1, 3, 9, 12, 13, 15, 20, 21, 24, 25, 32, and 33.

In the construction and maintenance of wing-dams the following materials were used: 1,062 cords of willows, 90 piles, 767 linear feet 12 by 12 inch timber, 71 screw-bolts, 51 drift-bolts, 68 cubic yards of stone, 259 cubic yards and 25 sacks of earth.

DREDGING.

From July 29 to November 5 dredging was done in the jetty channel, at times when the weather and the condition of the boat permitted, in order to prevent a possible shoaling to less than the required depth.

On November 5 while the boat was proceeding down the channel to empty the tanks of the material just dredged, her starboard boiler exploded, killing two men and

badly wrecking the forward part of the boat, which narrowly escaped sinking in mid-channel. A careful investigation failed to reveal the cause of the explosion.

The repairs were not completed till early in April, by which time the effect of the high river, in deepening the channel, rendered dredging unnecessary. The time during which dredging was done amounted to thirty-seven days of ten hours each.

THE PLANT.

Extensive repairs were made to the dredge-boat, and repairs to a tug-launch, four steel barges, and a pile-driver; also to two wharves. In the latter the following materials were used: 50 piles, 583 linear feet of 12 by 12 inch timber, 3,628 feet, B. M., 2 by 12 inch lumber, 18 screw-bolts, and 36 drift-bolts.

FORCE EMPLOYED.

The average force employed during the year, including officers, mechanics, and laborers, was 52 in number.

EXAMINATIONS AND SURVEYS.

As previously stated this report contains not only the results of examinations and surveys made during the year, but also those for a period of years, and, as the same methods of presenting them have been followed for several years, only general remarks to aid in understanding them will be necessary.

The results of tidal, sediment, and velocity observations are given on Chart No. 7.

AT THE HEAD OF THE PASSES.

The chart of this survey is No. 5. Since this survey was made, however, considerable change has taken place in the channel at this locality, though of a temporary character. A short time previous to May 17 a large volume of sand moving along the bottom, as it does when the river is high, lodged just above the entrance to South Pass, reducing the depth in some places 10 to 15 feet. The channel was not obstructed, however, as there was a depth of 30 feet and a 26-foot channel 650 feet wide further to the westward. This volume of sand is gradually moving out, and by the time the river reaches its low stage the channel will have resumed its normal condition.

The changes during the year in the depth over the area covered by this survey are unimportant and of no special interest. A deepening resulted, as we would expect, during the high river. The same result obtains in comparing recent results with those obtained in 1875.

By reference to the comparative profiles on Chart No. 6, the great increase in the depth of the channel into South Pass will be better understood. This, of course, is the result which the contractor desired to accomplish, and it has remained permanent for many years.

The present depth from the main river into South Pass is 28.7 feet, and the 26-foot channel is 580 feet wide. At no time during the year has this channel been less than the above dimensions.

SURVEY OF SOUTH PASS FROM ITS HEAD TO SOUTH PASS LIGHT-HOUSE.

During the month of October, while the river was low, I made a complete survey of South Pass, the charts of which are Nos. 3 and 4. As compared with a survey made a year previous some reaches shoaled and others deepened, though a general result is in favor of a slight shoaling during the year.

The greatest shoaling took place in the reach from five-eighths of a mile to 2¼ miles above South Pass Light-house, and varies from 1 to 4 feet in vertical height.

The greatest deepening occurred in the reach from 7¼ to 8¾ miles above South Pass Light-house, and varies from 2 to 5 feet.

The results obtained from surveys made in 1875, 1888, and 1889 are compared on Chart No. 6, from which the changes throughout the pass may be studied in detail.

The least depth in the pass during the year obtained during the month of May in Grand Bayou Reach, and at a locality 7 miles above South Pass Light-house; the central depth at both places was 27 feet, and the 26-foot channel was 320 feet wide at the former and 170 feet wide at the latter locality.

The shoalest place in the pass at the present time is in Grand Bayou Reach, where the central depth is 27.5 feet, and the 26-foot channel is 150 feet wide.

At other localities throughout the pass the depth and width of channel is substantially as shown on Charts 3 and 4, from which the following table is compiled:

Tabulated statement of the depth and width of channel throughout South Pass of the Mississippi River, from East Point to 30-foot depth in the main river, given in separate reaches one-fourth of a mile in length, from a survey made in October, 1889.

Locality.		Least available depth.	Least width for—		Locality.		Least available depth.	Least width for—	
From—	To above East Point.		26-foot depth.	30-foot depth.	From—	To above East Point.		26-foot depth.	30-foot depth.
East Point	¼ mile	27.6	280	(1)	Above East Point—Continued.				
Above East Point:					6 miles	6¼ miles	28.7	490	(9)
¼ mile	½ mile	28.6	360	(2)	6¼ miles	6½ miles	29.2	470	(10)
½ mile	¾ mile	32.0	310	160	6½ miles	6¾ miles	31.0	410	240
¾ mile	1 mile	32.7	310	130	6¾ miles	7 miles	33.5	410	320
First mile		27.6	280		Seventh mile		28.7	410	
1 mile	1¼ miles	29.3	310	(3)					
1¼ miles	1½ miles	29.1	280	(4)	7 miles	7¼ miles	32.0	480	200
1½ miles	1¾ miles	27.7	350	(5)	7¼ miles	7½ miles	32.8	410	330
1¾ miles	2 miles	28.4	350	(6)	7½ miles	7¾ miles	36.8	350	300
					7¾ miles	8 miles	41.3	340	270
Second mile		27.7	280		Eighth mile		32.0	340	200
2 miles	2¼ miles	30.3	430	140					
2¼ miles	2½ miles	35.0	420	280	8 miles	8¼ miles	36.7	350	260
2½ miles	2¾ miles	34.7	420	360	8¼ miles	8½ miles	37.3	350	260
2¾ miles	3 miles	33.4	420	350	8½ miles	8¾ miles	38.2	280	230
					8¾ miles	9 miles	38.0	240	200
Third mile		30.3	420	140	Ninth mile		36.7	240	200
3 miles	3¼ miles	32.4	380	220					
3¼ miles	3½ miles	31.3	380	130	9 miles	9¼ miles	34.0	260	140
3½ miles	3¾ miles	30.6	410	120	9¼ miles	9½ miles	28.3	350	(11)
3¾ miles	4 miles	32.7	410	270	9½ miles	9¾ miles	33.3	360	220
					9¾ miles	10 miles	51.8	350	300
Fourth mile		30.6	380	120	Tenth mile		28.3	260	
4 miles	4¼ miles	33.0	420	300					
4¼ miles	4½ miles	33.8	470	310	10 miles	10¼ miles	36.3	350	280
4½ miles	4¾ miles	35.7	460	250	10¼ miles	10½ miles	37.0	300	240
4¾ miles	5 miles	39.2	310	170	10½ miles	10¾ miles	33.0	280	210
					10¾ miles	11 miles	33.0	370	290
Fifth mile		33.0	310	170	Eleventh mile		33.0	280	210
5 miles	5¼ miles	31.0	300	90					
5¼ miles	5½ miles	28.2	430	(7)	11 miles	11¼ miles	44.0	(*)	(*)
5½ miles	5¾ miles	28.5	240	(8)	11¼ miles	11½ miles	30.0	(*)	500
5¾ miles	6 miles	30.2	320	30	11½ miles	11¾ miles	30.3	(*)	(*)
					11¾ miles	12 miles	30+	(*)	(*)
Sixth mile		28.2	240		Twelfth mile		30.0	(*)	500

*Very wide

Length of the portion of this reach lacking a central depth of 30 feet.

	Feet.
(1)	1,320
(2)	730
(3)	800
(4)	1,320
(5)	1,320
(6)	1,320
(7)	1,320
(8)	280
(9)	330
(10)	530
(11)	550
Total length of channel (in 12 miles)	9,920

THE CHANNEL THROUGH THE JETTIES.

The channel through the jetties is shown on Chart No. 1, and from comparative profiles on Chart No. 6 it will be seen that from a point 2,400 feet below East Point the channel deepened very much during the year, though not uniformly.

Up to November 5 dredging was necessary in order to maintain the required channel, yet, notwithstanding, a deficiency in the central depth just between the sea ends of the jetties was found to exist October 1, and before it was rectified the boiler of the dredge-boat gave out. On account of the delay occasioned in making the necessary repairs the required depth was not restored till October 6, thus making five days during the year when the required central depth of 30 feet did not exist.

The following table gives the least depth and width of channel through the jetties, and from it the changes in the depth and width from month to month during the year may be followed:

Tabulated statement regarding the minimum depth and width of channel through the jetties, in separate reaches of 2,000 feet each, according to surveys made monthly during the fiscal year ending June 30, 1890.

Date.	Distances from East Point, in feet.								
	0–2,000.			2,000–4,000.			4,000–6,000.		
	Least depth.	Least width for—		Least depth.	Least width for—		Least depth.	Least width for—	
		26-foot depth.	30-foot depth.		26-foot depth.	30-foot depth.		26-foot depth.	30-foot depth.
1889.									
June	30.4	320	100	32.2	340	200	31.3	310	170
July	30.3	260	50	31.0	300	120	31.0	300	100
August	31.7	310	80	31.4	330	160	31.5	300	70
September	30.9	310	50	31.3	340	170	31.2	270	80
October	31.6	320	60	31.0	320	140	31.2	270	60
November	31.0	320	60	31.2	320	120	31.2	280	100
December	30.8	320	100	31.0	310	110	31.2	270	80
1890.									
January	30.8	320	80	30.8	330	130	31.2	300	90
February	31.7	270	150	30.7	350	60	31.5	300	170
March	36.4	260	170	33.2	340	220	34.0	280	170
April	33.4	270	130	36.0	340	250	35.0	300	220
May	32.0	300	150	34.0	350	220	34.0	320	210
June	32.0	340	170	33.5	350	240	33.0	310	220

Date.	Distances from East Point, in feet.								
	6,000–8,000.			8,000–10,000.			10,000–12,000.		
	Least depth.	Least width for—		Least depth.	Least width for—		Least depth.	Least width for—	
		26-foot depth.	30-foot depth.		26-foot depth.	30-foot depth.		26 foot depth.	30-foot depth.
1889.									
June	31.5	230	120	31.0	220	100	30.8	210	90
July	32.4	230	120	31.3	220	90	31.0	220	100
August	31.6	230	110	31.4	220	80	31.0	220	70
September	31.0	220	50	31.1	210	40	.....	.....	.....
October	31.0	220	80	31.7	220	45	*29.6	210	(*)
November	31.0	220	80	31.3	220	60	31.4	215	50
December	31.0	225	80	31.7	220	60	31.2	210	40
1890.									
January	30.6	250	80	31.0	230	60	31.0	220	40
February	32.6	250	170	34.4	250	200	33.0	250	190
March	34.0	245	200	34.0	270	210	33.6	260	220
April	35.0	230	200	38.7	270	230	34.5	280	210
May	36.0	260	200	39.0	280	220	34.0	270	220
June	34.0	250	210	39.8	270	200	35.0	250	150

*From October 1 to October 5, both dates inclusive.

During the month of April the channel beyond the ends of the jetties and on a direct course from them to sea, shoaled so that the central depth was reduced at 28.3 feet. The central depth of this channel is now 28.7 feet, and the 26-foot channel is 400 feet wide.

The other channel turning to the eastward maintained during the year; the present depth of it is 32.3 feet, the 26-foot channel being 330 feet wide and the 30-foot channel 140 feet wide.

The following table is a record of the minimum depths through the jetties from month to month during the past fifteen years:

Table giving the depths of water through the jetties at various dates.

Date.	Distances from East Point, in feet.					
	0 to 2,000	2,000 to 4,000.	4,000 to 6,000.	6,000 to 8,000.	8,000 to 10,000.	10,000 to 12,000.
1875—June	22.5	18.7	16.7	10.2	9.7	9.2
1876—May	23.3	20.3	22.0	21.0	17.1	15.0
August	23.5	19.6	21.0	23.5	23.0	19.8
November	22.0	20.3	21.1	21.2	21.1	20.3
1877—March	24.1	21.1	23.2	22.0	21.2	20.5
July	24.9	24.0	26.0	23.8	23.5	20.3
October 25 to December 14	26.3	24.4	28.5	24.2	23.0	23.7
1878—March	26.0	25.9	35.5	25.4	24.3	23.0
December	28.4	26.4	35.7	27.1	25.3	23.0
1879—March	28.6	27.5	43.4	27.0	27.0	27.0
June	27.5	28.4	47.7	29.2	29.2	28.0
July	30.5	30.7	.....	31.0	30.7	30.5
December	31.0	31.0	48.3	31.7	31.8	30.8
1880—June	31.0	32.5	47.8	31.4	35.1	32.0
July	30.5	31.0	44.0	30.8	31.5	30.5
August	30.5	30.4	46.0	32.0	32.0	30.0
September	30.7	31.0	44.4	30.6	32.0	31.5
October	31.0	31.5	41.0	30.3	31.0	30.5
November	30.6	31.0	40.3	30.8	30.9	30.3
December	30.9	30.6	43.0	30.8	31.0	30.3
1881—January	30.5	30.4	41.9	33.8	30.7	30.3
February	30.4	30.2	41.6	32.0	31.0	30.0
March	31.5	31.2	41.3	32.0	32.0	30.5
April	30.4	30.0	43.0	33.0	33.0	30.5
May	30.2	30.5	42.7	32.6	30.5	31.2
June	30.0	30.5	43.8	32.0	31.7	31.7
July	31.0	32.0	42.5	33.5	33.0	32.0
August	30.1	32.0	37.6	32.0	31.0	30.2
October	30.2	30.3	38.3	31.4	31.2	30.3
November	30.8	31.8	39.2	30.4	30.0	30.1
December	30.2	32.8	39.4	30.8	30.2	30.0
1882—January	30.5	30.4	41.3	31.1	30.2	30.7
February	31.8	36.0	39.7	30.5	30.8	30.2
March	31.2	30.6	39.2	30.8	31.6	32.5
April	31.7	32.6	39.6	30.5	30.3	33.0
May	30.5	32.5	39.4	31.0	31.3	31.0
June	30.8	35.5	39.0	31.2	31.3	31.0
July	30.0	32.7	38.7	30.6	31.3	31.5
August	30.3	32.2	38.1	31.8	31.8	30.5
September	30.1	31.5	38.3	31.9	30.8	30.5
October	30.0	31.0	37.1	31.0	31.4	31.2
November	30.0	32.0	38.1	21.5	31.2	31.2
December	31.0	31.0	37.0	31.2	31.0	30.4
1883—January	31.0	31.0	35.2	30.2	30.1	30.1
February	31.2	31.2	36.0	30.5	30.0	30.1
March	32.3	32.6	45.7	31.5	30 3	30.3
April	33.7	35.0	44.0	32.2	30.0	39.0
May	33.2	36.3	46.0	32.3	30.3	32.4
June	32.5	34.2	45.0	33.4	31.0	33.0
July	33.8	34.9	44.0	32.0	31.5	31.8
August	32.1	38.2	48.0	33.4	33.4	32.2
September	33.4	34.3	46.0	32.3	32.3	30.6
October	32.7	34.1	41.5	32.0	32.0	30.5
November	31.0	33.8	43.8	34.5	31.5	31.0
December	30.5	32.6	43.0	31.6	31.6	30.2
1884—January	31.2	32.2	39.2	32.7	31.8	30.3
February	32.0	31.5	41.3	31.6	31.0	30.7
March	35.7	39.5	41.6	34.0	33.8	38.7
April	35.3	37.3	41.5	31.7	32.7	35.4
May	34.9	35.8	42.3	34.3	35.1	33.0
June	35.0	35.8	41.1	34.0	35.0	35.0
August	31.9	35.8	41.9	33.9	35.0	32.0
September	32.0	34.0	39.0	33.1	33.7	33.5
October	31.1	33.4	38.6	32.6	32.6	32.5
November	32.8	32.8	37.2	32.2	32.4	30.8
December	31.6	32.6	37.1	31.1	31.5	31.4
1885—January	36.7	36.4	36.9	33.1	34.6	32.8
February	41.7	36.3	35.7	30.5	34.1	36.2
March	35.5	36.0	36.1	31.0	31.7	35.7
April	36.0	35.5	37.0	32.0	32.6	32.0
May	36.7	35.0	35.6	31.5	33.5	31.5
June	34.7	33.7	35.7	32.8	32.8	31.3
July	36.3	33.1	36.5	33.7	33.6	31.0

Table giving the depths of water through the jetties at various dates—Continued.

Date.	Distances from East Point, in feet					
	0 to 2,000	2,000 to 4,000.	4,000 to 6,000.	6,000 to 8,000.	8,000 to 10,000.	10,000 to 12,000.
1885—August	36.5	35.6	37.6	33.0	32.6	31.0
September	35.3	33.3	35.2	32.2	30.7	31.7
October	33.8	33.7	35.8	31.3	30.4	30.4
November	32.7	32.8	35.1	30.8	30.6	30.1
December	33.0	32.2	34.2	30.9	30.5	30.6
1886—January	33.6	32.5	33.0	30.2	30.2	28.5
February	32.8	32.8	34.1	31.3	30.9	30.0
March	32.8	35.8	34.0	35.0	33.1	32.0
April	35.4	34.5	34.5	33.7	33.7	31.0
May	35.9	35.6	34.2	31.0	36.0	34.4
June	38.2	35.2	33.4	33.2	34.5	36.5
July	36.7	36.7	36.2	32.8	32.7	37.0
August	35.0	36.3	35.7	34.8	33.8	34.7
September	34.5	35.6	34.6	33.7	33.6	33.0
October	35.0	36.2	34.4	33.0	34.1	33.0
November	34.5	35.6	34.8	32.9	33.0	33.5
December	34.0	35.0	35.3	33.6	32.6	33.0
1887—January	33.6	34.0	33.3	32.3	32.7	33.4
February	36.4	34.4	35.4	31.3	34.1	32.4
March	35.5	35.5	32.6	35.5	35.5	33.8
April	38.8	37.0	33.7	31.0	34.8	35.5
May	39.4	35.3	37.1	31.2	34.2	38.1
June	39.0	35.4	37.5	32.3	34.1	35.2
July	39.0	36.4	35.8	34.0	32.0	34.0
August	35.7	34.6	34.7	33.6	31.6	32.7
September	36.0	34.0	35.0	35.0	32.7	32.2
October	36.2	34.2	34.3	32.1	32.2	31.8
November	35.9	32.9	33.8	30.7	31.8	31.2
December	34.7	32.7	33.9	30.9	31.7	31.8
1888—January	35.6	32.5	33.7	30.5	31.5	32.2
February	34.3	32.4	32.5	31.0	31.0	32.0
March	34.0	33.0	32.6	30.5	31.3	30.9
April	36.3	34.8	33.8	31.0	35.0	31.4
May	35.2	35.2	34.3	31.6	33.6	33.0
June	32.0	33.0	33.0	31.4	35.5	33.2
July	34.2	34.0	33.8	31.0	31.9	33.6
August	33.7	33.7	33.7	31.2	31.2	33.2
September	32.7	32.7	32.8	30.8	31.0	32.0
October	33.3	33.3	32.3	30.6	30.4	30.4
November	31.8	32.8	31.7	30.6	30.6	30.8
December	31.4	32.4	31.6	30.3	*29.2	30.7
1889—January	31.0	31.3	30.6	30.3	31.0	30.9
February	32.4	32.5	31.8	32.8	31.0	32.5
March	30.2	32.2	30.4	32.3	31.8	31.6
April	30.8	32.1	31.2	32.8	31.8	30.6
May	30.8	32.0	30.7	32.6	31.2	30.8
June	30.4	32.2	31.3	31.5	31.0	30.8
July	30.3	31.0	31.0	32.4	31.3	31.0
August	31.7	31.4	31.5	31.6	31.4	31.0
September	30.9	31.3	31.2	31.0	31.1	.....
October	31.6	31.0	31.2	31.0	31.7	†29.6
November	31.0	31.2	31.2	31.0	31.3	31.4
December	30.8	31.0	31.2	31.0	31.7	31.2
1890—January	30.8	30.8	31.2	30.6	31.0	31.0
February	31.7	30.7	31.5	32.6	34.4	33.0
March	36.4	33.2	34.0	34.0	34.0	33.6
April	33.4	36.0	35.0	35.0	38.7	34.5
May	32.0	34.0	34.0	36.0	39.0	34.0
June	32.0	33.5	33.0	34.0	39.8	35.0

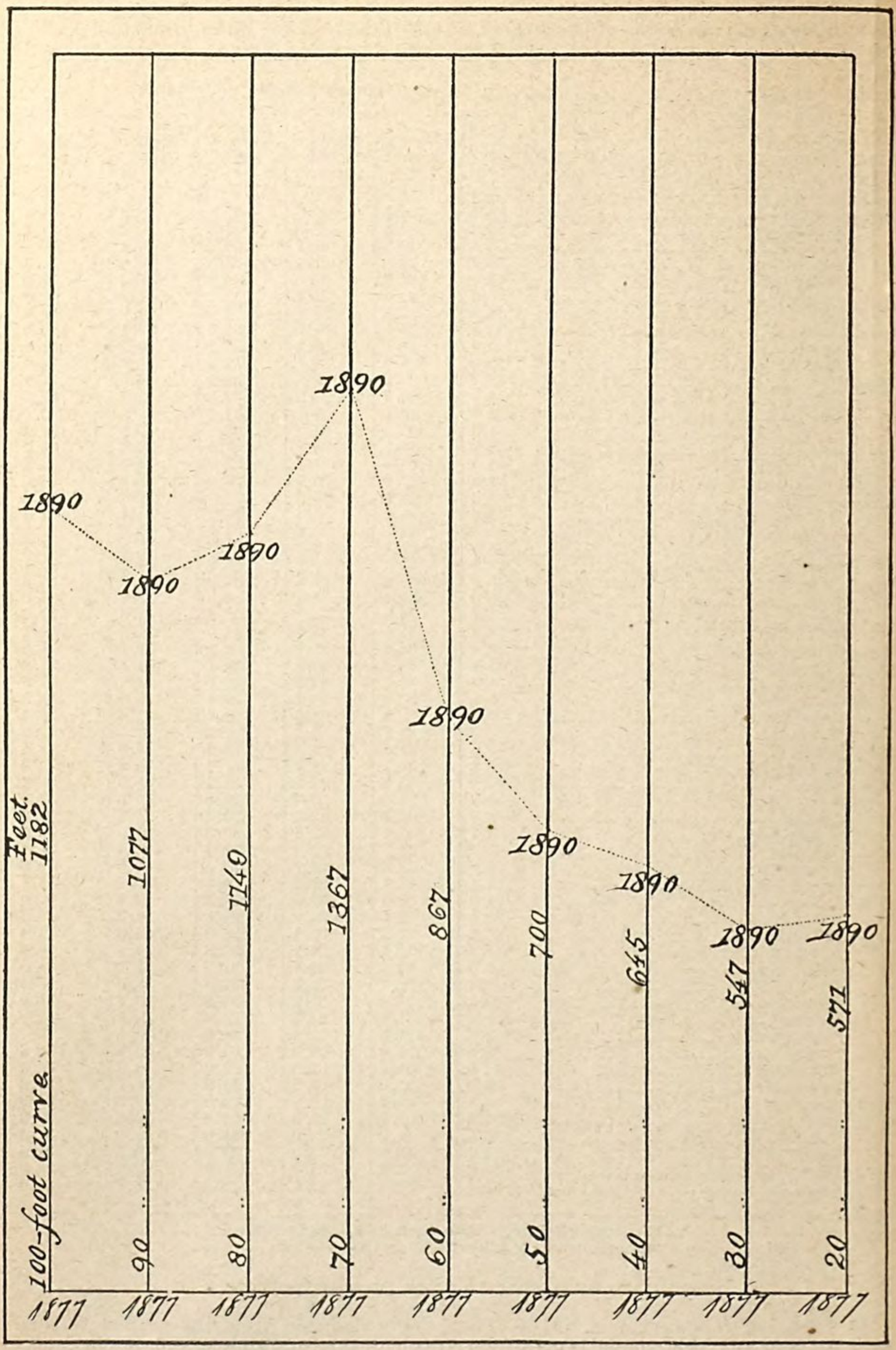
* From December 28, 1888, to January 4, 1889, inclusive.
† From October 1 to October 5, inclusive.

SURVEY BEYOND THE ENDS OF THE JETTIES.

The chart of this survey is No. 2. The results deduced from these surveys from year to year and the comparisons which are made are of interest and importance, and they are presented in such a manner that full information concerning them may be obtained.

By reference to chart No. 8 it will be seen that all the curves considered, that is, from 20 to 100 feet, inclusive, advanced during the year, the 40-foot curve showing the least advance, of 31 feet, and the 50-foot curve the greatest, of 163 feet.

The following diagram shows the advance of each curve from 1877 to 1890, the 30-foot curve showing the least advance, of 547 feet, and the 70-foot curve the greatest, of 1,367 feet.


100-foot curve
Feet.
1182
1077
749
1267
827
700
549
547
575
90
80
70
60
50
40
30
20
1890
1890
1890
1890
1890
1890
1890
1890
1890
1877
1877
1877
1877
1877
1877
1877
1877
1877

It will appear evident that over the area represented on chart No. 2 there are localities which undergo greater or less changes than do others, and in order to determine the localities of greatest and least change, and also the amount of the same, I consider an area containing 1¼ square miles, and by obtaining its mean depth and that of each of 21 lesser areas into which it is divided, and comparing the results with similar ones obtained for previous years, the vertical height of the shoaling or deepening in each division and over the whole area is obtained.

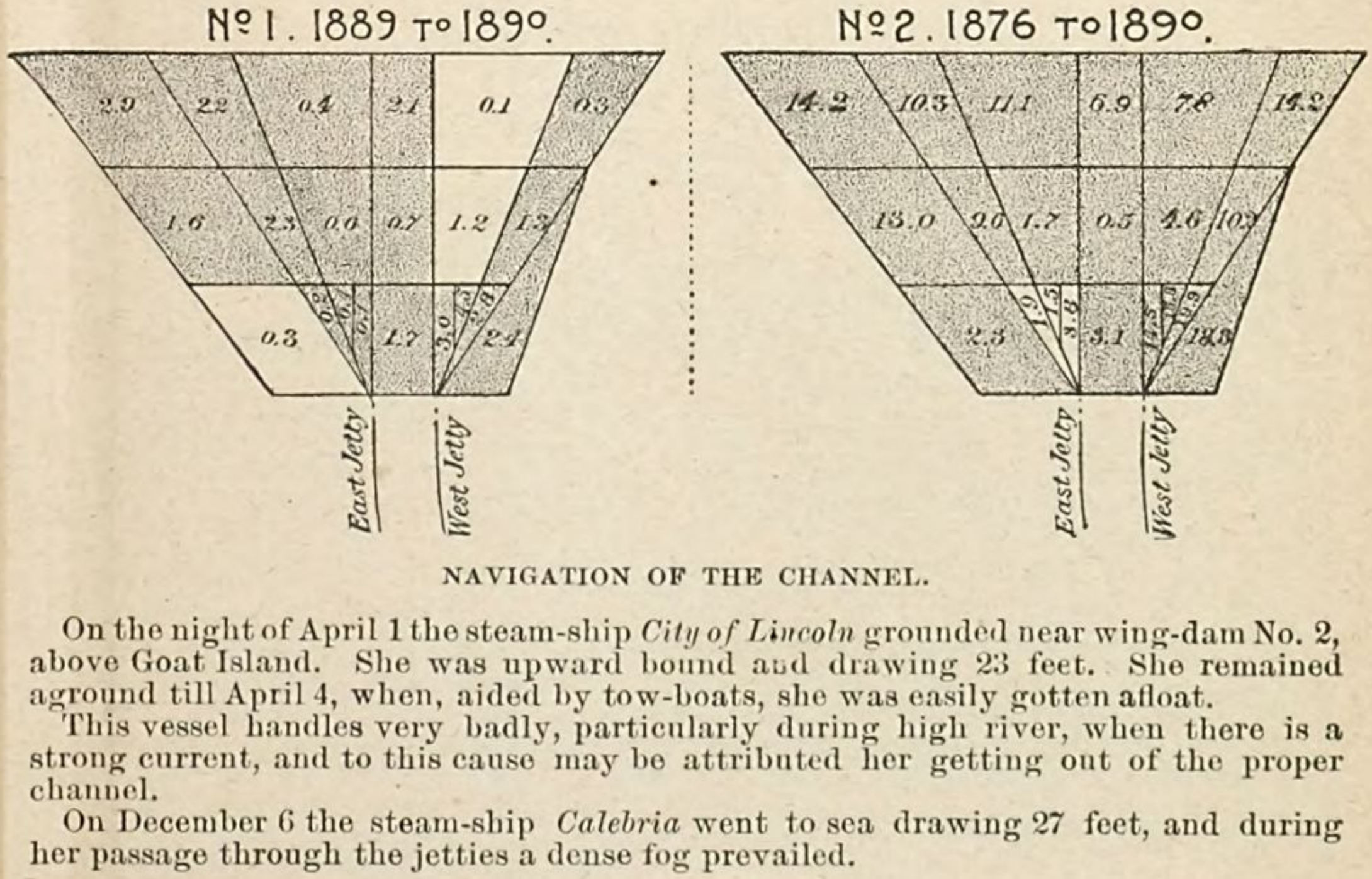
Having learned that all the curves advanced during the year and since 1877, it follows that the result of these determinations will be a shoaling during the same periods.

The results from year to year since 1876 are as follows:

Years.		Mean change over whole area.		Years.		Mean change over whole area.	
From—	To—	Deepened—	Shoaled—	From—	To—	Deepened—	Shoaled—
1876	1877	.....	0.40	1884	1885	1.16	.....
1877	1878	1.80	.....	1885	1886	.....	0.12
1878	1879	.....	2.56	1886	1887	.....	1.38
1879	1880	0.12	.....	1887	1888	.....	0.31
1880	1881	.....	2.38	1888	1889	1.23	.....
1881	1882	.....	1.30	1889	1890	.....	1.11
1882	1883	0.04	.....				
1883	1884	.....	3.61	1876	1890	.....	8.82

The following diagrams which represent this area and its subdivisions will explain the change in each division as well as the character and amount of the same.

No. 1 results from comparing the mean depths for 1889 with those for 1890, and No. 2 compares those for 1876 with those for 1890. The figures in each division being the amount in feet and tenths of a foot that each has shoaled or deepened; shaded areas having shoaled and blank areas deepened.



NAVIGATION OF THE CHANNEL.

On the night of April 1 the steam-ship *City of Lincoln* grounded near wing-dam No. 2, above Goat Island. She was upward bound and drawing 23 feet. She remained aground till April 4, when, aided by tow-boats, she was easily gotten afloat.

This vessel handles very badly, particularly during high river, when there is a strong current, and to this cause may be attributed her getting out of the proper channel.

On December 6 the steam-ship *Calebria* went to sea drawing 27 feet, and during her passage through the jetties a dense fog prevailed.

CONCLUSION.

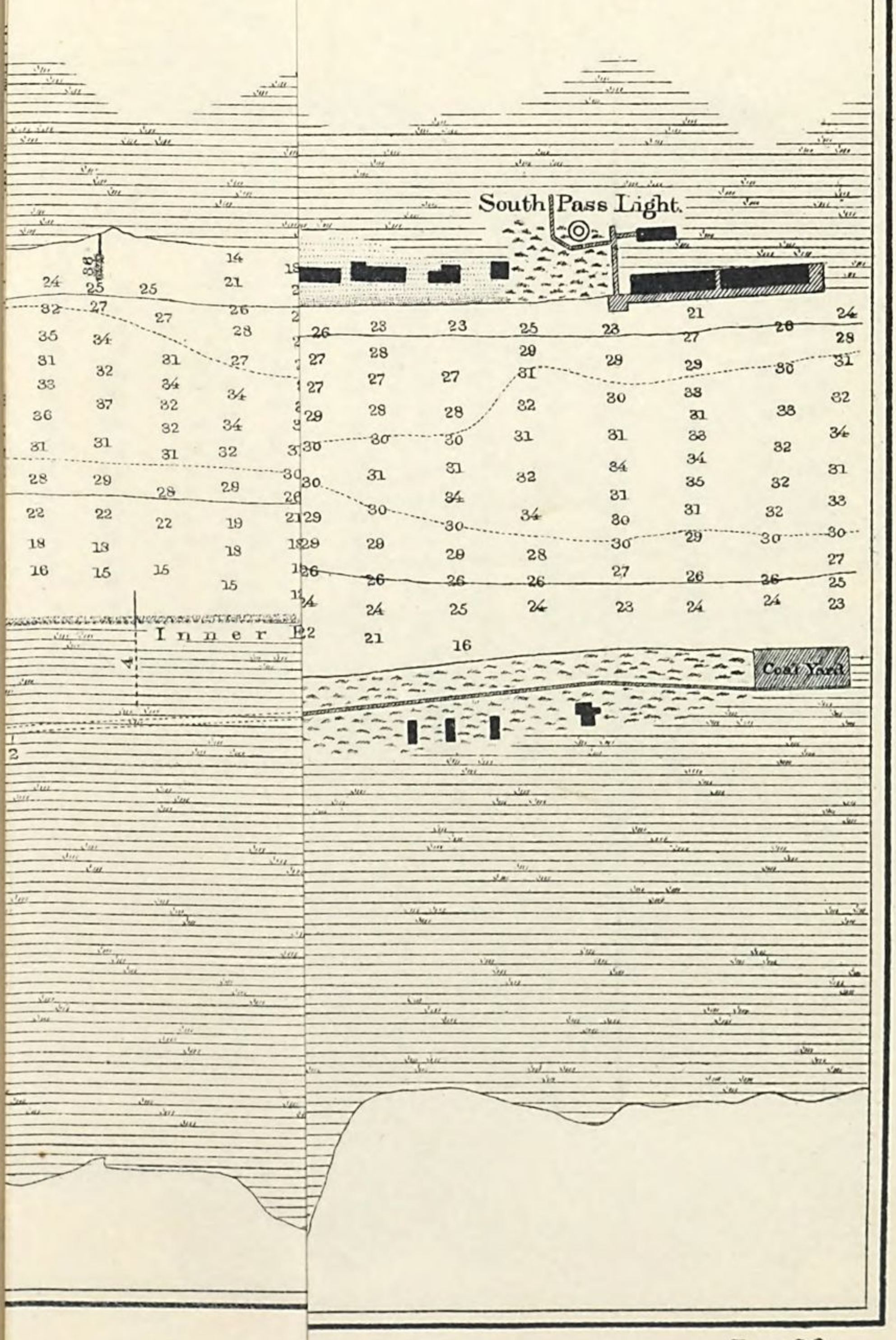
During the year I was assisted by Recorder G. W. Lawes whom I desire to commend.

Very respectfully, your obedient servant,

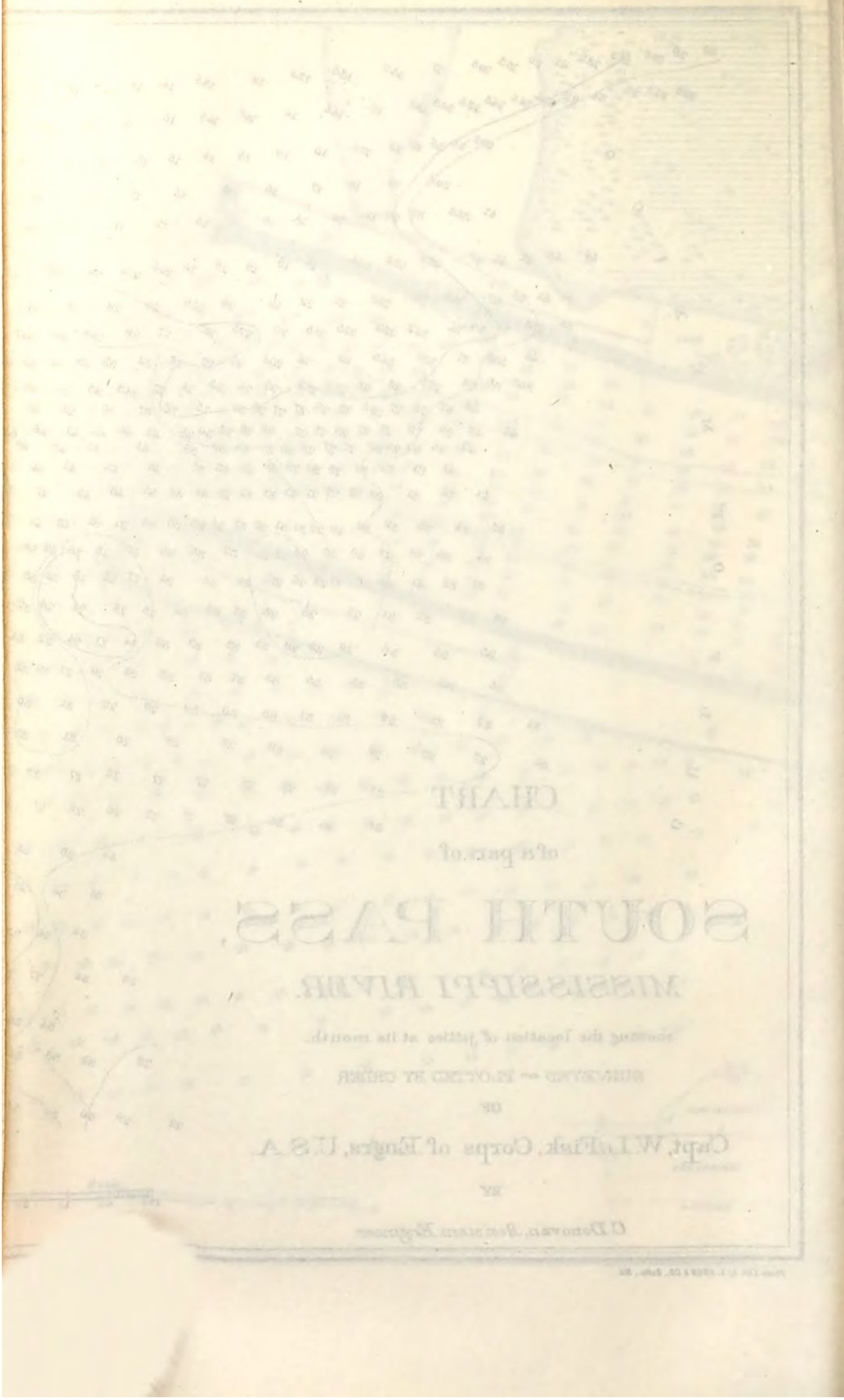
C. DONOVAN,
Assistant Engineer.

Capt. W. L. FISK,
Corps of Engineers, U. S. A.

No. 1.

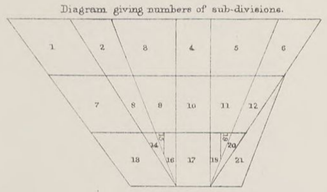


Eng 90



Whistling Buoy

Diagram giving numbers of sub-divisions.



Note.

Depths are expressed in feet, and refer to the plane of average flood tide, indicated by a reading of 2.76 feet on U.S. Engineer's gauge near South Pass light house.

Soundings April 29,30, May 1, 7, 1890.

Carrollton gauge reading 14 feet.

SCALE

100 0 1 2 3 4 5 6 7 8 9 1000 2100 ft

East Jetty

West Jetty

True Meridian

No2.

CHART

of a part of

GULF OF MEXICO,

seaward from the ends of

SOUTH PASS JETTIES,

to a depth of 100 feet.

Surveyed and plotted

BY

C Donovan, Assistant Engineer.

To accompany annual report for the year ending June 30th 1890.

W. H. Bixby

Captain of Engineers, U.S.A.

Photo-Lith. by A. HOEN & CO., Balto., Md.

		27	80
12		184	254
46	242	312	300
02	310	300	292
02	312	307	
77		280	288
82	292	290	287
90	290	282	284
92	282	272	284
90	274	264	270
80	270	266	262
70	264	272	240
40	284	162	
30	222		

281

Nº 3.

CHART

OF THE

HEAD OF PASSES,

MISSISSIPPI RIVER.

showing location of jetties, dykes, dams, etc.

SURVEYED AND PLOTTED BY ORDER

OF

Capt. W.L. Fisk, Corps of Engrs, U.S.A.

BY

C. Donovan, Assistant Engineer.

Note.

Depths are expressed in feet and tenths of a foot, and refer to the plane of average Flood tide indicated by a reading of 24 feet on U.S. Engineer's gauge near Head of Passes light-house.

Soundings March 17, 24, 25, and April 4, 5, 1880.

Carrollton gauge 76 to 153 feet.

26 foot curve ——— 30 foot curve - - - - -

Scale.

1nch 0 1 2 3 4 5 6 7 8 9 10 11 12 1200 feet.

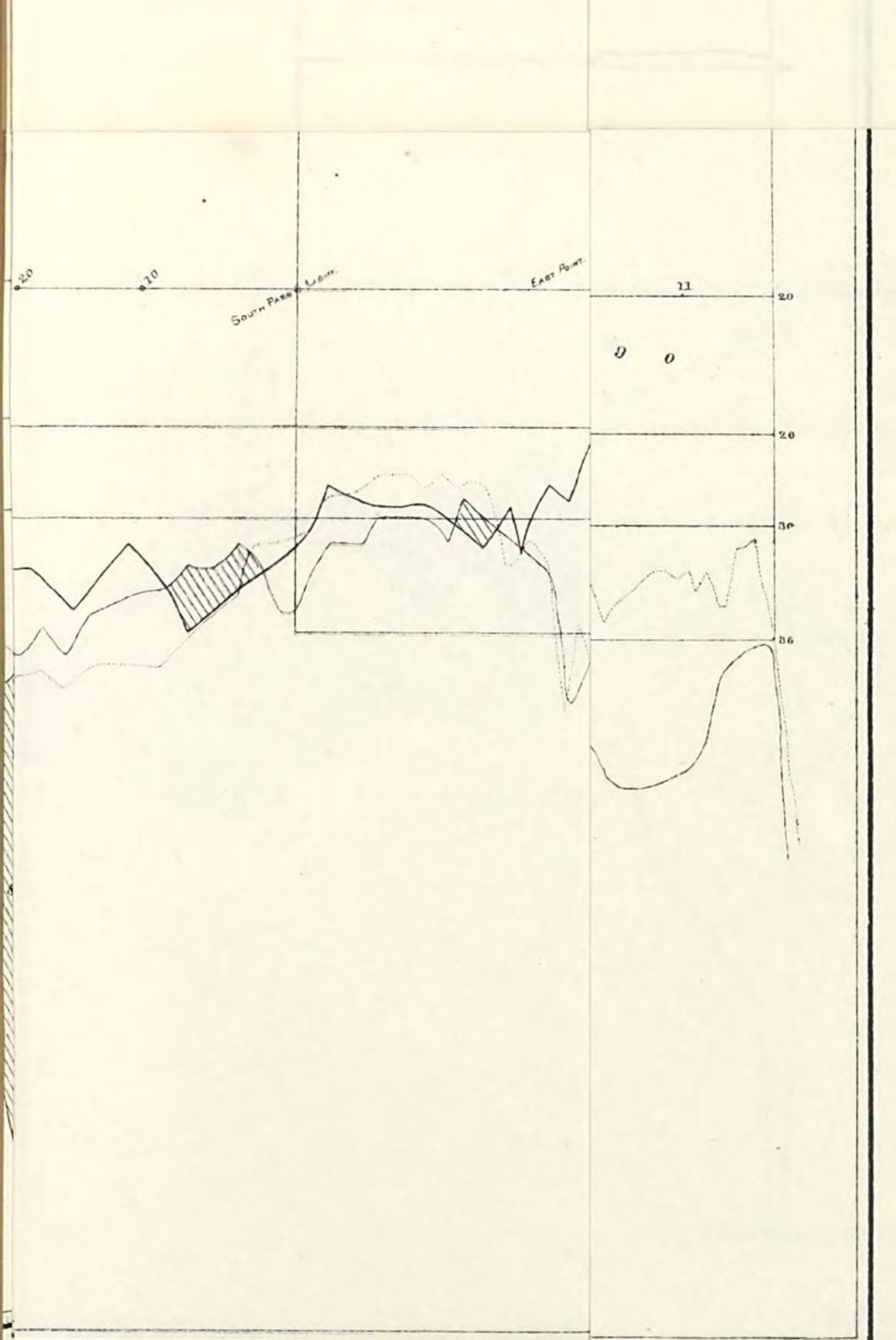
To accompany annual report for the year ending June 30th 1880.

W. L. Fisk.

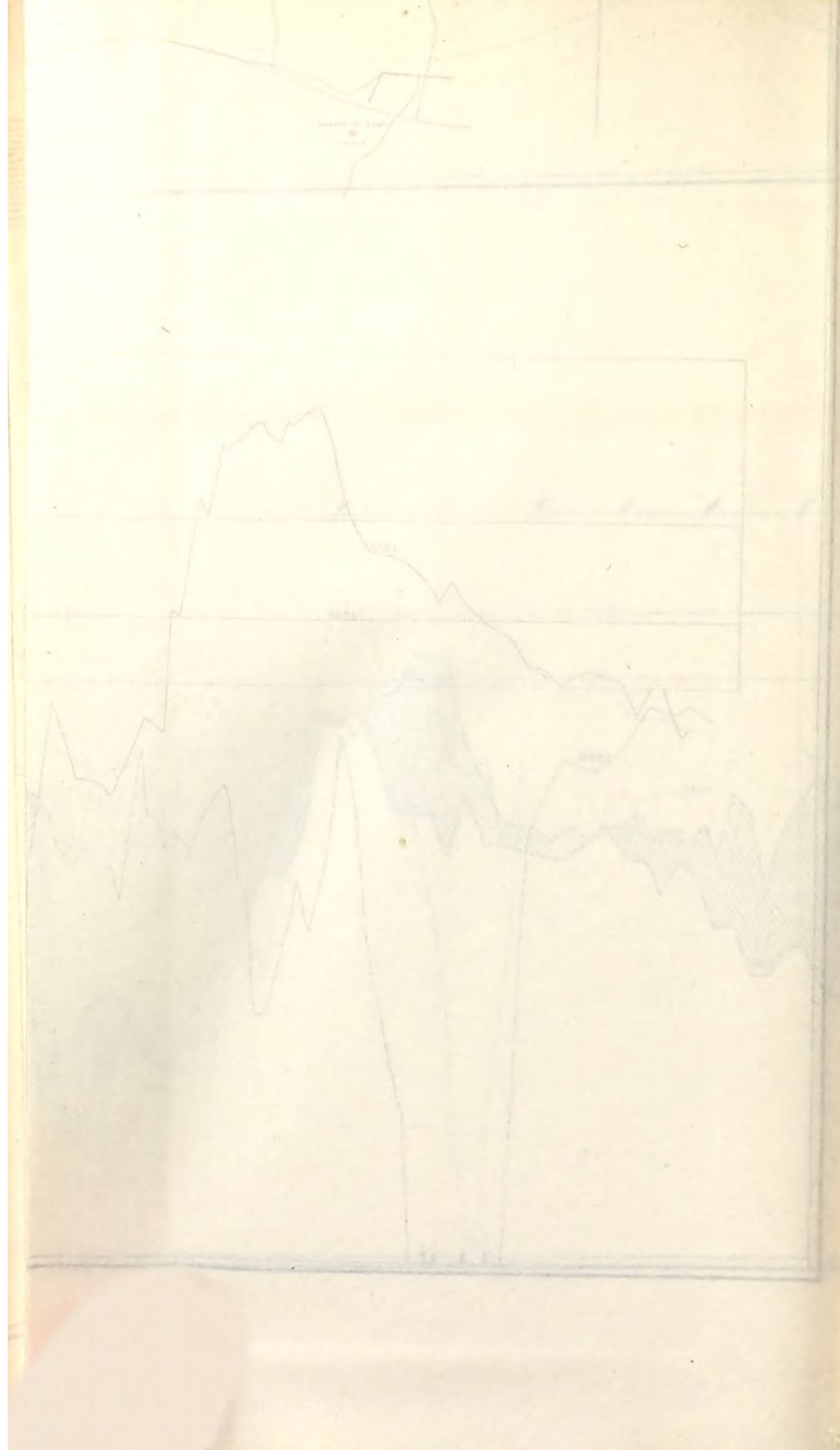
Captain of Engineers, U.S.A.

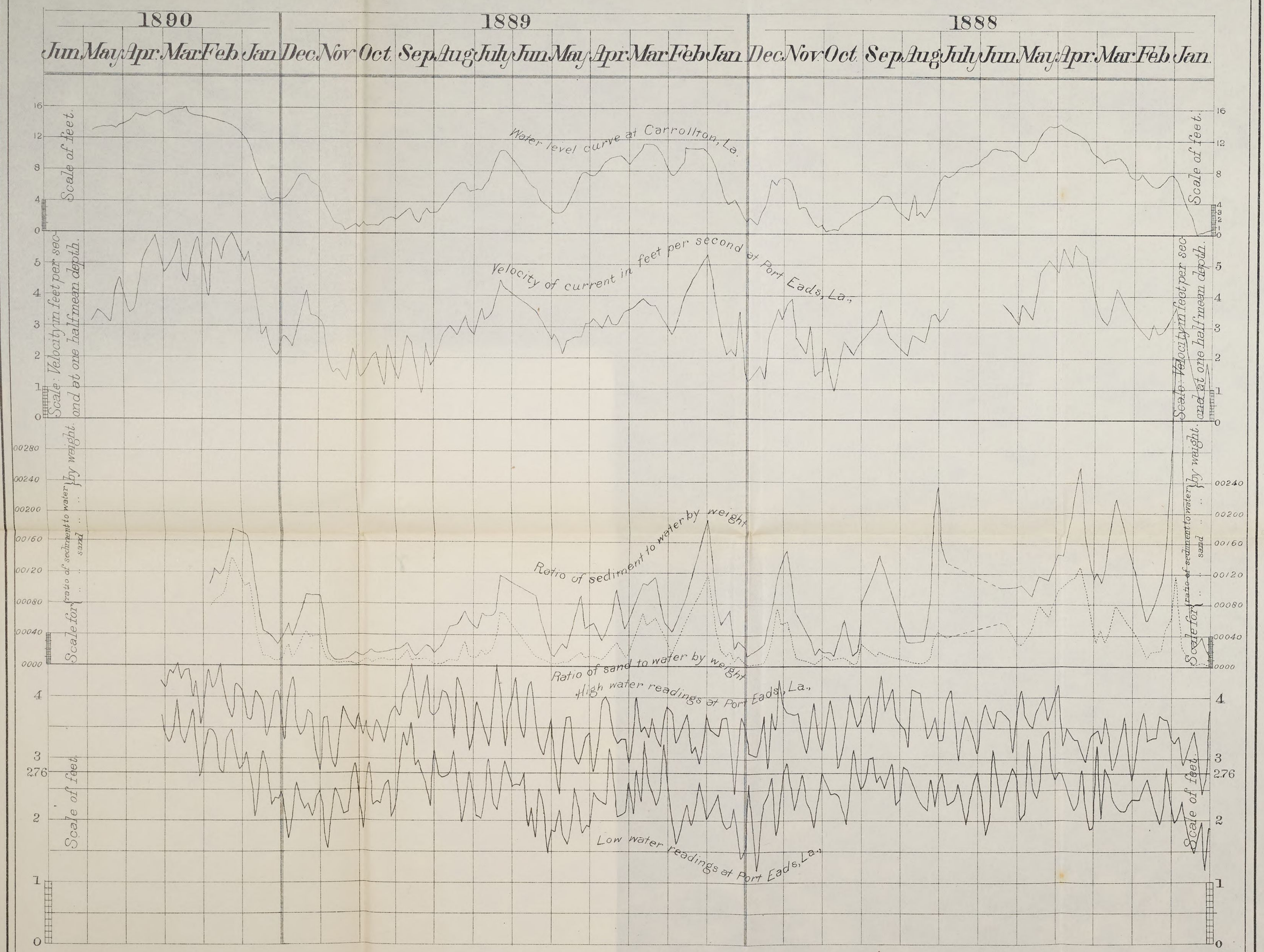
Eng 90.

Photo-Lith. by A. HOEN & CO., Balto., Md.



& CO., Balto., Md.



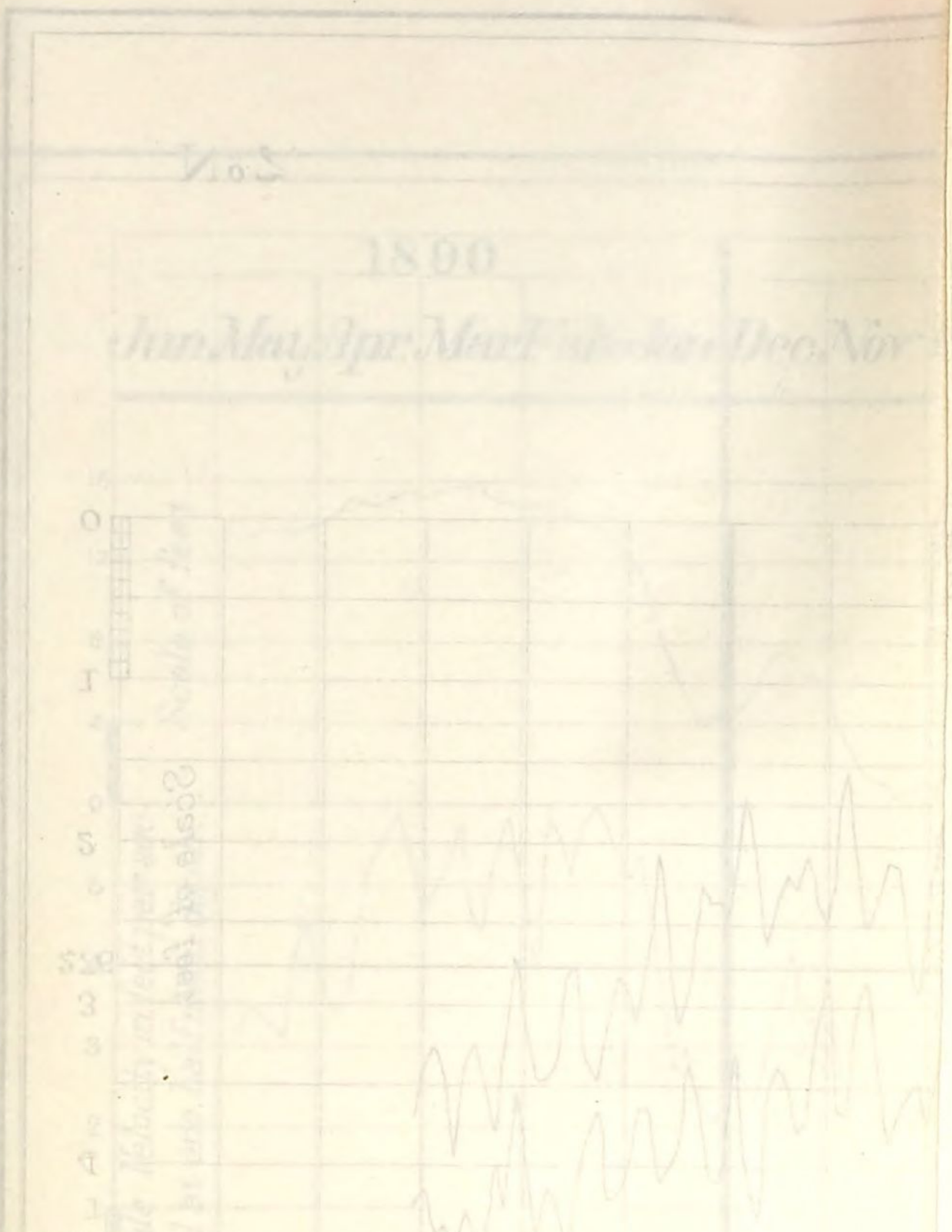


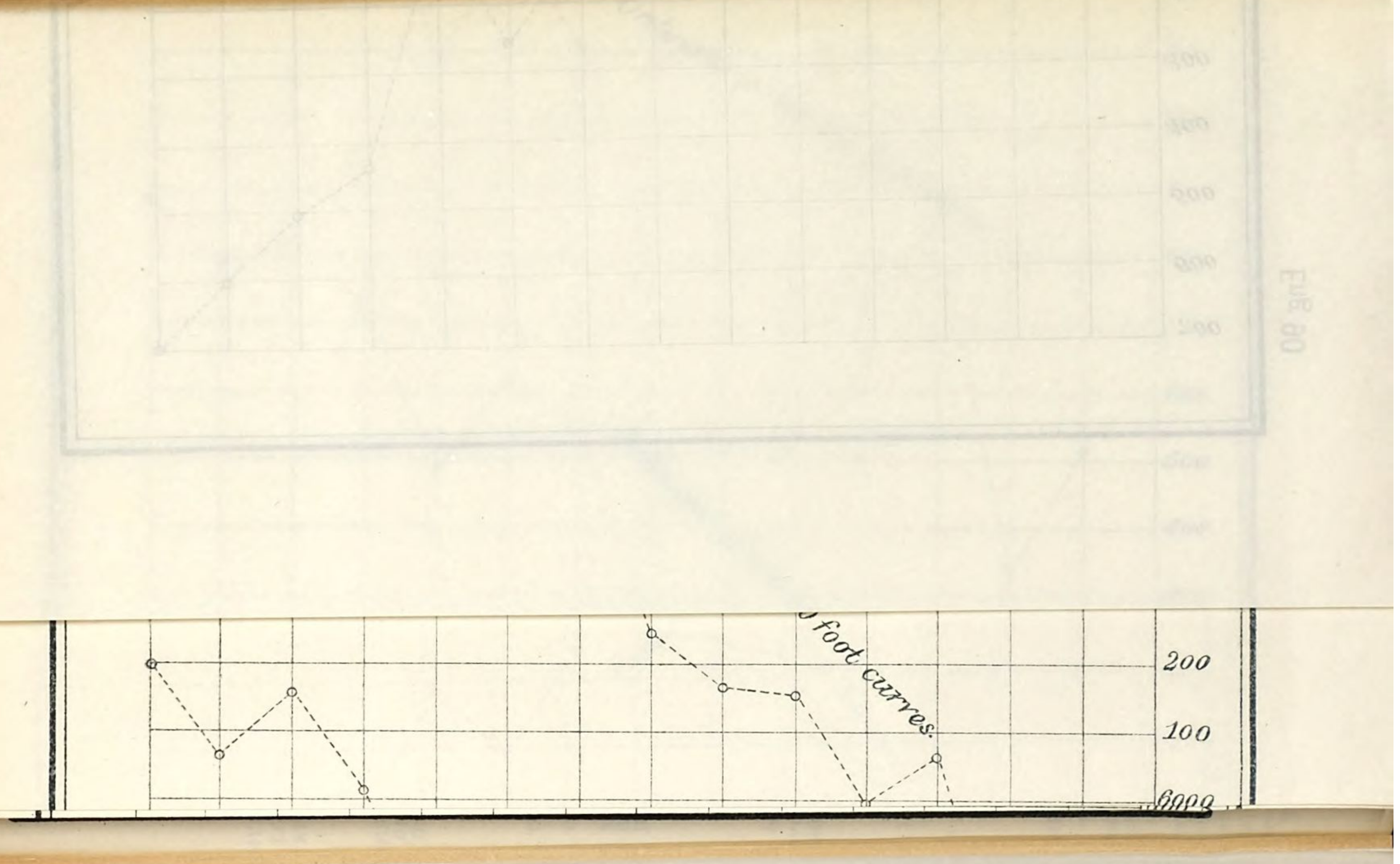
To accompany annual report for the year ending June 30th, 1890.

W. L. Fisk.
Captain of Engineers, U.S.A.

№ 7.

Photo-Lith. by A. HOEN & CO., Balto., Md


1890
Jan.
May.
Sept.
Dec.
Nov.
$30
3
2
1
0
S
0
1
2
3


foot curves.
200
100
6000

APPENDIX T.

IMPROVEMENT OF THE VARIOUS WATER-COURSES IN THE STATE OF LOUISIANA—IMPROVEMENT OF SABINE PASS AND OF SABINE AND NECHES RIVERS, TEXAS.

REPORT OF CAPTAIN W. L. FISK, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1890, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

IMPROVEMENTS.

1. Tchefuncte River and Bogue Falia, Louisiana.
2. Tickfaw River and its tributaries, Louisiana.
3. Amite River, Louisiana.
4. Bayou Lafourche, Louisiana.
5. Bayou Terre Bonne, Louisiana.
6. Bayou Plaquemine, Louisiana.
7. Bayou Courtableau, Louisiana.
8. Calcasieu River and Pass, Louisiana
9. Sabine River, Louisiana and Texas.
10. Neches River, Texas.
11. Sabine Pass, Texas.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., July 8, 1890.

GENERAL: I have the honor to transmit herewith annual reports for river and harbor works under my charge for the year ending June 30, 1890.

Very respectfully, your obedient servant,

W. L. FISK,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

T 1.

IMPROVEMENT OF TCHEFUNCTE RIVER AND BOGUE FALIA, LOUISIANA.

The project for the improvement of this river was made in 1880, and contemplated the removal of overhanging trees, logs, etc, in the channel and the dredging of the bar at its mouth.

The first appropriation of $1,500 was made March 3, 1881, and a second one of $1,500 in August, 1882. With these two appropriations the obstructions below Covington were removed, and part of the unexpended balance was used for the construction of a working plant for improving the bar at the mouth and part for the construction of a breakwater extending 820 feet into the lake.

The third appropriation for this work, $2,500, made August 5, 1886,

was expended in improving Bogue Falia between Old Landing and Covington, by cutting a channel 5 feet in depth and 30 to 60 feet in width through the bars between these places.

The original estimate for improving this river was $5,460, the greater portion of which was for dredging the bar at the mouth.

It was thought, however, that a dredged channel over this bar could not be maintained without protecting works, which would cost considerably more than the dredging. Major Stickney, who had this work in charge, caused a re-examination to be made in 1884, and in his report in the Annual Report of the Chief of Engineers for 1884, Vol. II, page 1269, he reports the river in good order except the bar at its mouth, and suggests as a method for improving this to build a jetty or breakwater 2,500 feet long across the bar into the comparatively deep water of Lake Pontchartrain, and then to dredge the channel through the bar, in the hope that the jetty would prevent, or at all events greatly retard, the refilling of the cut with sand.

The estimated cost of this improvement is $20,400, and if anthorized by Congress, this amount should be appropriated for the fiscal year ending June 30, 1892, and applied to extending the breakwater, dredging the bar, and removing any other obstructions that may have formed since the river was cleared out.

Should the improvement be made as contemplated, the protection of the mouth of the river would also enable vessels navigating the lake to use it as a harbor of refuge in gales.

The depth of water on the bar at its lowest stage (during a norther) is about 4½ feet. The benefit to commerce is local. It is not known that there has been any increase of commerce in consequence of improvements thus far made. Should Congress desire to carry out the project for making the mouth of the Tchefuncte a harbor of refuge, then $20,400 will be required to do this. Otherwise no money for the further improvement of this stream during the fiscal year ending June 30, 1892, is required.

The following, compiled from various sources, are the best available statistics of the commerce of this stream:

Number of vessels, 1889–'90	31
Total registered tonnage of same	602.40
Aggregate number of trips out of river	414
Aggregate tonnage of same	7,980.65

Articles.		June 1, 1888, to May 31, 1889.		June 1, 1889, to May 31, 1890.	
		Quantity.	Value.	Quantity.	Value.
Lumber	feet..	5,039,000	$75,585	4,417,000	$66,255
Staves		.....	.....	37,000	740
Shingles		584,000	1,752	.....	.....
Wood	cords..	4,065	16,260	3,419	13,676
Brick		1,330,000	13,300	469,000	4,690
Sand	barrels..	63,540	15,885	57,465	14,366
Cotton	bales..	2,007	100,350	1,471	73,550
Total	tons..	36,092	.....	30,158	.....
Miscellaneous freight into the river estimated at two-thirds of outward freight in tonnage and three-fourths in value	tons..	24,000	169,000	20,000	130,000
Total	tons..	60,092	392,132	50,158	303,277

Money statement.

Amount appropriated by act of September 19, 1890 ..... $1,000.00

T 2.

IMPROVEMENT OF TICKFAW RIVER AND ITS TRIBUTARIES, LOUISIANA.

This work was commenced in 1879 by an examination authorized by Congress. The estimated cost of the improvement was $10,230, and the project was to clean out this stream as well as its navigable branches, the Natalbany, Blood, and Ponchatoula, by removing such obstacles to navigation as snags, logs, stumps, and overhanging trees.

In 1881 Congress appropriated $2,000 to commence the work. Work was done by contract in 1882, and 16 miles of Tickfaw River were cleaned out.

In 1882 $2,000 more was appropriated; this was expended partly in building plant, and the work of cleaning out the stream was done with this plant and hired labor; the result was a good navigable channel 9 miles above the previous head of navigation on the Tickfaw.

In 1886 Congress appropriated $2,000 more, the funds to be available for cleaning out the navigable branches of the Tickfaw. In the latter part of 1886 and early part of 1887 work was resumed with Government plant and hired labor and the branches cleared to the head of navigation.

In 1888 Congress appropriated $1,000 for the Tickfaw and its navigable tributaries; the latter being in good condition the Government snagging plant commenced on the river itself early in May, 1889, removing the obstructions that had re-formed since 1887, and worked upstream to within 1 mile of the Chapman place, where work ceased, the appropriation being exhausted.

The navigable portions of the Tickfaw and its tributaries are now in good condition, but the improvement will not be permanent, as obstructions will again form in consequence of freshets and the careless felling of timber on the banks.

An appropriation of $1,000 annually will keep all these streams in good condition.

The following, compiled from various sources, are the best available statistics of the commerce of this stream:

Number of vessels, 1889–'90	9
Total registered tonnage of same	189
Aggregate number of trips out of river	82
Aggregate tonnage of same	1,481

Articles.		June 1, 1888, to May 31, 1889.		June 1, 1889, to May 31, 1890.	
		Quantity.	Value.	Quantity.	Value.
Lumber	feet	1,173,000	$17,595	1,178,000	$17,670
Shingles		300,500	900	35,000	105
Staves		21,300	420	130,000	2,600
Wood	cords	665	2,660	742	2,968
Sand	barrels	2,075	519	559	137
Cotton	bales	542	27,100	730	36,500
Total	tons	4,957	.....	5,511	.....
Miscellaneous freight into the river estimated at two-thirds of outward freight in tonnage and three-fourths in value	tons	3,000	36,000	3,700	4,500
Total	tons	7,957	85,194	9,211	104,980

Money statement.

July 1, 1889, amount available	$18.20
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	18.20
Amount appropriated by act of September 19, 1890	1,000.00

T 3.

IMPROVEMENT OF AMITE RIVER, LOUISIANA.

The original project for improving this river was adopted in 1880; the object was to obtain at low water a channel 5 feet in depth as far upstream as appropriations would permit, the main portion of the work to be done being above the mouth of Bayou Manchac.

In 1880 Congress appropriated $8,000 for this work, and contract was made for $7,650 for improving 40 miles of the river. In 1881 $5,000 more was appropriated, which it was proposed to use for extending the work beyond the point where the first contract should terminate.

The successful bidder for the second contract failed to furnish bonds, so the contract was not completed. The work under the first contract was accepted in 1883, was poorly done, and only 17 miles of river was cleared. In 1883 the project was modified and approved so as to clear out obstructions below the Bayou Manchac with Government plant and hired labor. This part of the work was well and economically done and resulted in clearing out about 8 miles of river. The officer in charge of the improvement in 1884 estimated that to work over the 17 miles of river first done by contract and complete that required farther down the river would cost $8,205.

In 1886 Congress appropriated $2,000. In November, 1886, the work was resumed by means of Government plant and hired labor and continued until January 31, 1887, during which time 2,754 stumps, logs, snags, and overhanging trees were removed from the bed and banks of the stream. Most of this work was done between the mouth of the Bayou Manchac and Port Vincent, about 5 miles below, where the river had become almost unnavigable from the accumulation of snags and other obstructions after the suspension of work in 1883. All serious obstructions to navigation below Fort Vincent were also removed. The Amite River was then in good navigable state. Examinations showed that it was useless to spend any more money on the Amite River above the mouth of the Bayou Manchac, for the reason that there is neither commerce nor navigation above this point. Although steam-boats have been 30 miles farther up the river, there is nothing to pay them for doing so. Besides, at low-water stages the depths are insufficient, and at high water the current is too swift to be steamed with economy.

The small balance remaining of this appropriation could only be expended on the Amite, not on its navigable branch, Bayou Manchac, and as it would have been a waste of public funds to have spent the balance on the upper portion of the river, work was discontinued in January, 1887, owing to its completion in accordance with the modified project.

In 1888 Congress appropriated $5,000, and stipulated that of this sum $2,500 might be used in improving Bayou Manchac. The snagging plant

was put in good order as soon as possible, and commenced work in November, 1888, in Bayou Manchac, working up from its mouth to Hereford Landing, removing 2,699 land slide trees, stumps, sunken trees, snags, saplings, tree tops, overhanging trees, and cluster bushes, leaving the Manchac in good condition up to that point, and beyond which it will hardly be advisable to extend the work. It was desired to excavate a turning basin for steam-boats just above Hereford Landing, but the money available for Bayou Manchac having been exhausted it could not be done.

The plant then returned to the mouth of the Bayou Manchac, cleared Amite River of all obstructions down to its mouth by May 1, removing 846 overhanging trees, land-slide stumps and trees, sunken trees, saplings, tree-tops, and cluster bushes, and then proceeded to the Tickfaw River for work.

The improvement will not be permanent, as caving banks and freshets will continue to carry in trees and snags. To keep these streams clean and to excavate a turning-basin for steam-boats at the head of navigation on Bayou Manchac an appropriation of $2,500 should be made for the year ending June 30, 1892, and should be available for work upon either Amite River or Bayou Manchac without limitation.

The following, compiled from various sources, are the best available statistics of the commerce of this stream:

Number of vessels, 1889–'90	26
Total registered tonnage of same	458.62
Aggregate number of trips out of river	515
Aggregate tonnage of same	10,853.77

Articles.	June 1, 1888, to May 31, 1889.		June 1, 1889, to May 31, 1890.	
	Quantity.	Value.	Quantity.	Value.
Lumber ..... feet..	5,395,000	$80,925	3,471,000	$52,065
Shingles	6,114,000	18,342	2,856,175	8,568
Staves	2,680,139	53,600	3,327,635	66,560
Wood ..... cords..	2,573	10,292	7,136	28,544
Brick	50,000	500	233,000	2,330
Sand ..... bbls..	1,350	337	9,040	2,260
Cotton ..... bales..	1,281	64,050	2,550	127,500
Cotton-seed ..... sacks..	2,362	1,605	6,086	4,140
Total ..... tons..	33,272	.....	48,160	.....
Miscellaneous freight into the river, estimated at two-thirds of outward freight in tonnage and three-fourths in value ..... tons..	22,000	172,000	30,000	215,000
Total ..... tons..	55,272	401,651	78,160	506,967

Money statement.

July 1, 1889, amount available	$624.04
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	110.00
July 1, 1890, balance available	514.04
Amount appropriated by act of September 19, 1890	3,800.00
Amount available for fiscal year ending June 30, 1891	4,314.04

T 4.

IMPROVEMENT OF BAYOU LA FOURCHE, LOUISIANA.

The original project for this work was adopted in 1879 from surveys authorized by act of Congress, March 3, 1873 (see Report of Chief of Engineers for 1874, Appendix S 5), the object being to improve low-water navigation of the bayou by removal of obstructions, such as snags, wrecks, raft-heaps, cutting of trees which obstructed navigation, etc.

On account of high water operations were suspended December 31, 1881, and resumed September 21, 1882. From this time till January 31, 1883, the work was carried on steadily to a point 30 miles below Lockport, when the funds being nearly exhausted and the water getting too high, the plant was taken to Lockport and laid up.

In the river and harbor act of August 22, 1882, provision was made for a survey of this bayou.

A preliminary report of this was forwarded on August 20, 1882, and in Department letter of April 25, 1883, it was directed that the survey should be made.

No work was done during the year ending June 30, 1884, the balance of available funds being too small to permit anything more than the payment of a watchman for the care of the boats.

On August 25, 1884, an amended project was submitted by Captain Turtle for continuing work down stream from where it had been suspended the previous year, and authority was received from the Chief of Engineers, under date of September 1, 1884, to carry on the work as recommended.

The work of overhauling the plant at Lockport was immediately commenced, and work was resumed September 22, 1884, and continued until January 15, 1885, when it was again stopped on account of high water, the plant ordered back to Lockport, and the crew discharged, except the suboverseer and cook, who were retained for further service on Bayou Teche. The plant was at the same time placed under the direction and orders of First Lieut. O. T. Crosby, Corps of Engineers.

By authority of the Chief of Engineers it was removed to Bayou Teche, serving en route as a quarter-boat for a survey party on Bayou La Rompe. It remained on the Teche from March, 1885, to January, 1887, engaged much of the time in snagging and wrecking operations.

After completion of the survey of 1883, examination of the level notes showed them to be unreliable, and in April, 1886, the level lines were re-run under the direction of Lieutenant Crosby.

During eight months of the year, when the water is high, the bayou is navigable for large size steam-boats.

During the fiscal-year 1886–'87 the water was exceptionally low, steam-boats could not get over the bar at the head of the La Fourche, and navigation by means of flat-boats was extremely difficult and irregular.

In 1888 Congress appropriated for—

> Improving Bayou La Fourche, Louisiana, pursuant to the project of Lieut. O. T. Crosby, Corps of Engineers, dated June 11, 1886, $50,000, including immediate dredging to secure low-water navigation.

The project referred to is the construction of a lock connecting with the Mississippi River at Donaldsonville, thus converting the Bayou into a salt-water canal, and subsequent dredging of the channel to a width

of 75 feet with a depth of 5 feet at mean low water of the Gulf of Mexico.

To this, as seen above, Congress added a proviso calling for immediate dredging to help out low-water navigation, which had been entirely suspended during the extreme low-water of 1887, even for small flat-boats drawing less than 2 feet of water.

The appropriation was made so late in the season it would have been impossible to advertise, make the contract, and get enough dredging done in the bayou to be of any appreciable benefit before the Mississippi River would rise enough to render it necessary for that season. At the head of the bayou was a bar whose surface was so high that during low water of 1887 it shut the river entirely out; it was therefore decided to dredge a channel 60 feet wide through this bar to a depth of 4 feet below mean low tide of the Gulf, hoping to thus admit enough water from the river to avoid the stoppage of the flat-boat navigation.

Accordingly specifications were prepared and the work advertised, bids to be opened on the 22d of September.

The only bid received, that of J. H. Gardner, of New Orleans, was for 45 cents per cubic yard. Under the urgent necessity existing, and because the amount of work to be done was small, this bid was accepted and contract entered into, the work to be completed by the 31st of October.

Unexpected trouble, caused by the sliding in of the sides of the cut, put the contractor back a little with his work, so it was actually completed November 9, 1888, under an extension of contract to November 30, granted by the Chief of Engineers.

Flat-boat navigation was suspended but a day or two, when the opening of the first cut through the bar, as had been hoped, admitted sufficient water to at once open it up again, and no further trouble was experienced during the season.

Authority was obtained to remove a number of snags at a cost not to exceed $1,000, but the river rose so rapidly as to render it advisable to postpone this work to the next low water.

The least depth of water that will insure continuous flat-boat navigation is 2 feet at mean low tide of the Gulf, and to secure this will require a total excavation of 150,000 cubic yards of material, more or less, from numerous bars scattered between Donaldsonville and Thibodeaux.

Specifications were prepared and the work duly advertised, bids to be opened June 10, 1889. The Alabama Dredging and Jetty Company was the only bidder, at 55 cents per cubic yard.

The amount of dredging required being about 150,000 cubic yards and the money available only one-half of what would be required at the price named, the bid was rejected. Under authority of the Chief of Engineers a dredge was hired and began work in the bayou September 11, 1889, continuing until January 18, 1890, when, the water having risen to such a height that satisfactory work could no longer be done, the dredge was discharged.

During the five months and seven days work the dredge removed from the channel 37,944 cubic yards of mud, many snags of all sizes, a number of old flat-boat and steam-boat wrecks, and a number of bars of railroad iron found near the bridge of the Texas and Pacific Railroad.

This work was all done within a distance of about 2 miles from the head of the bayou, and opened a channel 2 to 3 feet deep at mean low water of the Gulf for that distance.

When the dredge began to work it was found that the bar at the head of the bayou had shoaled again materially, so it was necessary to redredge it.

Much of the other work had to be gone over twice and some of it three times, owing to the material being of the nature of quicksand and continually running back into the cut.

It is probable that at next low water there will be little if any traces of the channel already dredged, so if it is to be the policy of Congress to have large amounts of dredging done every year the best plan will be to at once build a dredge suited to the conditions there found.

A dredged channel can not be expected to be permanent so long as the sediment-bearing water of the Mississippi River is allowed free access to the bayou, and therefore should properly not be done until after the lock is built.

The lock and necessary dredging were estimated by Lieutenant Crosby, in his report of June 11, 1886, referred to in the act of Congress, at $450,000, and it was urgently recommended that if the work was to be done it should be all appropriated at once. I desire to repeat their recommendation and to add that I doubt very much if $50,000 expended annually in dredging will suffice to keep the bayou open. The lock once built, any dredging done will be practically permanent, as the small amount of river water used in locking through boats will not carry enough sediment to materially damage the channel below.

The cost of maintenance of slackwater navigation was estimated at $30,000 annually.

The saving of freight paid in consequence of slackwater navigation if made, was estimated at $19,000 annually.

The following, compiled from various sources, are the best available statistics of the commerce of this stream:

Number of vessels, 1889–'90	8
Total registered tonnage of same	2,357
Aggregate number of trips out of river	330
Aggregate tonnage of same	96,010

Articles.		June 1, 1888, to May 31, 1889.		June 1, 1889, to May 31, 1890.	
		Quantity.	Value.	Quantity.	Value.
Sugar	hogsheads	19,226	$1,828,614	32,425	$2,621,598
Sugar	barrels	37,503		37,561	
Molasses	do	35,502	284,016	44,790	358,320
Rice	sacks	74,564	242,334	108,650	353,112
Potatoes	do	33,472	66,944	46,653	91,306
Onions	do	6,182	12,364	21,781	43,562
Hides	bundles	404	6,464	327	5,232
Moss	bales	2,471	14,826	1,780	10,680
Miscellaneous freight		1,490	29,800	3,132	62,640
Total	tons	33,169	.....	47,502	.....
Inward freight.					
Coal	tons	65,000	214,500	80,000	264,000
Miscellaneous freight	do	71,000	1,420,000	99,000	1,980,000
Total	do	169,169	4,119,862	226,502	5,790,450

Money statement.

July 1, 1889, amount available	$46,842.91
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	11,435.42
July 1, 1890, balance available	35,407.49
Amount appropriated by act of September 19, 1890	50,000.00
Amount available for fiscal year ending June 30, 1891	85,407.49
Amount (estimated) required for completion of existing project	400,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	100,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

T 5.

IMPROVEMENT OF BAYOU TERRE BONNE, LOUISIANA.

In 1879 Congress ordered an examination of this stream. The estimated cost of improvement in 1880 was $18,800. This was for dredging and removing logs, snags, and other obstructions. As the examination on which this estimate was based was made in high water it was incorrect, and the same officer making the first estimate increased it by $20,000, making the total estimate $38,800.

Appropriations made are as follows:

June 14, 1880	$10,000
March 3, 1881	8,800
August 2, 1882	7,000
August 5, 1886	10,000
August 11, 1888	3,000
Total	38,800

Dredging was commenced in 1880; was continued in 1881 from a point about 23½ miles below Houma, La. This was contract work, and about 7½ miles of channel was improved. In 1882 work was resumed with Government plant and hired labor, and completed to within about 10½ miles of Houma. In 1886 work was again resumed by Government plant and hired labor and about 164,165 cubic yards were dredged out and 41 miles advanced during the year 1886–'87. Work was continued until December 17, 1887, when the channel was completed to the railroad depot at Houma, and a turning-basin dug there, thus completing it, according to project, $3,000 within the estimate.

The bayou between its low-water banks was of less width than the dredge-boat; consequently, to do any work, she had to first cut a channel of her own width and then cut turn-outs or passing-places every few hundred yards to enable floating, sailing, or steam craft to pass. When this improvement was commenced the Bayou Terre Bonne was in places little more than a drainage ditch.

Where the dredge began work the bayou was but 11 feet wide. Nearly every plantation on the bayou has a drainage ditch emptying into the bayou, and below the mouth of each ditch a bar has formed so that work done by the dredge one year is frequently obliterated during the next.

The improvement enables planters on the bayou to float their prod-

uce to Houma, the nearest railroad station, instead of hauling it there over wagon roads, and it drains the neighboring country.

The improvement will never be permanent unless the drainage ditches emptying into the bayou are closed and the drainage turned towards the swamps.

The following, compiled from various sources, are the best available statistics of the commerce of this stream:

Number of vessels, 1889–'90	2
Total registered tonnage of same	76.20
Aggregate number of trips out of river	29
Aggregate tonnage of same	326.45

Articles.		June 1, 1888, to May 31, 1889.		June 1, 1889, to May 31, 1890.	
		Quantity.	Value.	Quantity.	Value.
Sugar	bbls.	11,623	$209,214	8,745	$157,416
Molasses	do	4,443	25,544	3,586	28,688
Rice	sacks	250	812	350	1,137
Potatoes	do	258	516	350	700
Moss	bales	12	72	24	144
Total	tons	3,076		2,394	
Inward freight.					
Coal	tons	1,000	5,000	1,500	7,500
Miscellaneous freight	do	1,340	179,000	1,160	133,000
Total	do	5,416	430,158	5,054	328,579

Money statement.

July 1, 1889, amount available	$3,519.67
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	524.88
July 1, 1890, balance available	2,994.79

T 6.

IMPROVEMENT OF BAYOU PLAQUEMINE, LOUISIANA.

To comply with the requirements of the river and harbor act of August 5, 1886, a preliminary examination and survey were made of the mouth of Plaquemine with a view to its connection with the Mississippi River by locks, and also Bayou Plaquemine and other connecting streams to form the best route to Grand Lake, La. The report of the result of the survey is printed in Senate Ex. Doc. No. 21, Forty-ninth Congress, second session, and also as Appendix S 21 of the report of the Chief of Engineers for 1887.

The proposed project provides for the opening of the water route indicated by removal of snags and dredging, and constructing a lock at the mouth of Bayou Plaquemine, at an estimated cost of $1,708,250.

The river and harbor act of August 11, 1888, appropriated $100,000 "for securing a navigable channel 60 feet wide and 6 feet in depth, from deep water up to the Plaquemine Dike, and for securing the mouth of the bayou from further caving." * * *

As this office had no plant available for protection work, while the

Mississippi River Commission had a large amount that must lie idle a considerable time before the next appropriation became available, it was recommended that the portion of this work relating to securing the mouth of the bayou from further caving be turned over to the officer in charge of the fourth district of the Mississippi River, thus avoiding the construction of an expensive plant for which there would be no use after completing this comparatively small amount of work.

This transfer was accordingly directed by letter of May 15, 1889, from the office of the Chief of Engineers, and $75,000 allotted for it.

To do the other part of the work—that is, to secure the navigable channel 60 feet wide and 6 feet deep up to the Plaquemine Dike—the Government dredge which had been at work at the mouth of the Neches River during the winter and spring was transferred to Bayou Plaquemine about the middle of May, a few minor repairs made, and dredging begun June 4, 1889, at Darden's Bend, about 5 miles below the town of Plaquemine. Up to and including June 30, 1889, 9,284 cubic yards were dredged.

The dredge continued working until stopped by high water, April 30, 1890, removing from the channel during the fiscal year 115,127 cubic yards of mud and 689 snags and logs, most of which it was necessary to first break up with dynamite.

The required channel is now completed for about one-half of the required length, but it is probable that considerably more than one-half the work yet remains to be done. Work will be resumed when the water has fallen sufficiently to allow it to be done satisfactorily.

The only use made at present of Bayou Plaquemine Channel is to run cypress logs up to the various mills near the town of Plaquemine.

Money statement.

July 1, 1889, amount available		$96,314.20
Amount reserved by Chief of Engineers		170.00
		96,484.20
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$42,538.76	
July 1, 1890, outstanding liabilities	5,709.00	
		48,247.76
July 1, 1890, balance available		48,236.44
Amount appropriated by act of September 19, 1890		100,000.00
Amount available for fiscal year ending June 30, 1891		148,236.44
Amount (estimated) required for completion of existing project		1,508,250.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		500,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

T 7.

IMPROVEMENT OF BAYOU COURTABLEAU, LOUISIANA.

Appropriations made for this work have been as follows:

June 14, 1880	$7,500
March 3, 1881	7,500
July 5, 1884	4,000
August 5, 1886	5,000
August 11, 1888	5,000

The project, made in 1879, contemplated closing all the bayous running out from the south bank of the Courtableau, with a view of forcing the current to cut away Little Devil Bar at the junction of the Courtableau with the Atchafalaya, then to construct locks and dams to make slackwater navigation, first to Port Barré, 17 miles up-stream, and then to Washington, La., 11 miles farther up.

The preliminary estimate for the cost of this work was $40,000, which was afterwards increased to $78,500, and it was reported in the annual report of 1886 that the cost of masonry lock and dam would be $175,000.

In 1882 dams were built on the Big and Little Fordoche bayous and timber was slashed into the smaller bayous, so as to concentrate the flow of water over Little Devil Bar. The result was favorable, and 3 feet increased depth of water was obtained in two days.

It was reported that the swampers cut one of these dams afterwards, and Little Devil Bar again shoaled up. In 1885 the cut dam was rebuilt and the other one repaired. A sudden rise caused one of these dams to break, but it was repaired, and during the following summer good results were hoped from the effect the two dams would produce.

In the summer of 1886 the Courtableau was exceptionally low, and Little Devil Bar was shoaler than ever. At its lowest stage a skiff could not be floated over the bar.

Lieutenant Crosby was sent to the Courtableau in September, 1886, to examine the stream prior to resuming work with the money appropriated the month previous.

From his report (Annual Report Chief of Engineers, 1887, page 1376) it will be seen that the prospects of success, even should all the run-out bayous be closed, are anything but certain, yet the closure of two of the principal outlets in one season did produce an increase of depth of 3 feet. In view of this fact, and that the project called for the closure of these bayous, work of dam-building was resumed in November, 1886.

Slight necessary repairs were made to the old dams in the Big and Little Fordoche, and a new dam was built in Bayou English.

Bayou Mamzelle was similarly closed, and the wings of the dam closing the Big Fordoche were repaired. At the time work ceased, early in November, the bar was cutting out rapidly, there being then a channel 3 to 5 feet depth, while when work began there was one of but a few inches.

The new channel was then of no use, however, as the closure of Old River permitted no boats to enter the Atchafalaya from the Mississippi River.

The high water of 1888 formed the bar again, as usual, depositing sand to a depth of probably 6 or 8 feet over a length of 2 miles.

A personal examination, made in October, 1888, during low water, showed that the preceding high water had cut around one end of each of the dams already built, but they had caused a sand-bar to form at each, varying in height from 2 to 3 or 4 feet above the water in the Courtableau at the time of the examination, thus forcing all the water in the bayou to pass out into the Atchafalaya across Little Devil Bar, the head of which was then some 300 or 400 yards above the Little Fordoche. The volume of water was considerably greater than usual at low water, due to heavy local rains, was running with great velocity, and was moving a large quantity of sand, as could be plainly seen, but the depth at the shoalest point could not have been greater than 18 inches. Had the bar been cut out to a suitable depth for navigation it is doubtful if it would have left sufficient water in the bayou above for purposes of navigation.

As soon as possible preparations were begun to repair the existing dams and to build others, closing some of the remaining outlets, but before the snagging plant which was to be used in doing the work could be put in repair the water rose to such a height that nothing could be done.

The water having fallen sufficiently, work was resumed September 2, 1889. The broken dams in Bayous Manzelle, English, and Fordoche were all repaired with piles and sheet-piles, brush-aprons placed above and below them, held down by sinking trees and earth, and left in good condition.

Bayous Big Cane and Little Cane, both small and of little importance, were obstructed by slashing trees in them, and the boats taken to Bayou Jurammon on November 23 for work, but the water rose so rapidly the plant and lumber had to be taken to Washington, laid up in good shape, and the crew discharged November 30; since which time the water has remained so high nothing could be done.

As soon as the water is low enough work will be resumed and pushed as rapidly as possible.

The estimated cost of completing the closure of these run-out bayous, in addition to what is on hand, is $2,107.90.

This amount can be expended in the year ending June 30, 1892.

The following, compiled from various sources, are the best available statistics of the commerce of this stream:

Number of vessels, 1889–'90	8
Total registered tonnage of same	1,727
Aggregate number of trips out of river	87
Aggregate tonnage of same	25,333

Articles.		June 1, 1888, to May 31, 1889.		June 1, 1889, to May 31, 1890.	
		Quantity	Value.	Quantity.	Value.
Sugar	hogshead..	3,407	$204,420	2,425	$145,500
Molasses	barrels..	3,287	26,296	1,680	13,444
Rice	sacks..	11,913	38,717	4,810	15,632
Cotton	bales..	21,230	1,061,500	48,195	2,409,750
Cotton-seed	sacks..	188,108	128,250	65,805	44,940
Hides	bundles..	226	3,616	620	1,920
Staves		52,516	4,200	30,680	2,446
Wood	cords..	3,574	14,296	1,888	7,552
Miscellaneous freight	tons..	470	9,400	.....	.....
Total	tons..	18,950	.....	20,974	
Miscellaneous	do....	13,000	1,123,000	.....	.....
Inward freight estimated at two thirds of outward freight in tonnage and three-fourths in value	tons..	.....	.....	14,000	1,980,000
Total	do....	31,950	2,613,695	34,974	4,621,184

The above is the combined traffic of Bayou Courtableau and Bayou Des Glaises, and they can not be accurately separated, but probably about one-half belongs to each stream.

Money statement.

July 1, 1889, amount available	$4,636.61
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	3,547.22
July 1, 1890, balance available	1,089.39
Amount appropriated by act of September 19, 1890	2,200.00
Amount available for fiscal year ending June 30, 1891	3,289.39

T 8.

IMPROVEMENT OF CALCASIEU RIVER AND PASS, LOUISIANA.

In 1874, and again in 1882–'83, dredged channels were cut through the flats in Calcasieu Lake above Calcasieu Pass. The dredged channel was 8 feet deep and 70 feet wide by 7,500 feet long. The work was done by contract.

In 1885 this channel had again shoaled to a depth of 3½ feet and needed redredging, but by an unfortunate wording of the appropriation, funds in hand for "Improving Calcasieu River" could not be applied to this particular work. In 1886 this was remedied, and funds heretofore appropriated for Calcasieu River became available for both the pass and the river.

Contracts were made in 1886 for building two revetment walls of piles and planks, one on each side of the proposed cut, to be about 130 feet apart, each to be a mile or more in length, and between these to dredge a channel 100 feet in width and 6 feet in depth, the excavated material to be thrown outside the revetment walls. In addition to this another bar at the mouth of the Calcasieu River at the northern end of the lake was giving occasional trouble, and the same contract also required the excavation of a channel through this bar 100 feet wide by 6 feet in depth. Work was commenced on the revetments in the winter of 1886, but the weather was so severe that the contractor and several of his men died from sickness due to exposure on this work.

In the spring of 1887 work was resumed by the administrator of the contractor's estate, and the revetment nearly completed. At the date of the annual report for 1887 a dredge was expected to begin work within a few weeks, and actually arrived there about the middle of August, but was not ready for work until the last of November on account of the repairs necessary and the delays in making them.

About the middle of September, when it was thought the dredge would be ready for work in a few days at the very latest, the administrator began driving down the planking of the revetment into the ditch the water had dug under it, but after one day's work stopped. After that time he did nothing, and although every effort was made to have him complete the work, he would not do so, and the contract was annulled January 3, 1888.

Authority was obtained from the Chief of Engineers to do the work by hired labor and open market purchase, using the Government dredge which had shortly before finished the improvement of Bayou Terrebonne. A careful examination developed the fact that the revetment was so badly wormed as to be worthless, and as this showed the life of timber to be short there, application was made to so far modify the project as to omit the revetment. The Chief of Engineers approved the modification January 12, 1888. The work of putting the dredge in condition was at once begun, and completed in about four weeks. Bad weather in the Gulf caused a few days' delay, as it was necessary to pick weather for the long outside tow of 200 miles, but the dredge arrived and began work on the 19th of March.

In the mean time two deck barges had been hired and arranged for use as dump-scows, but two days' work with them showed that the wooden shafts or Spanish windlasses used for closing the dumping doors were not strong enough; these were replaced with 3-inch iron shafting and worked well.

The dredge took out in all 77,159 cubic yards, completing the work August 31, 1888.

The work will not be permanent.

In 1888 Congress appropriated $10,000 for continuing this improvement, but as the work was completed according to the approved project this money will be held until further work is required.

In consequence of competing water-route to market, the rates of freight on lumber by rail from Lake Charles to Texas ports are about $2 per 1,000 feet less than at other localities where the railway haul is less.

The following, compiled from various sources, are the best available statistics of the commerce of this stream:

Number of vessels, 1888–'89	34
Total registered tonnage of same	1,243.58
Aggregate number of trips out of river	
Aggregate tonnage of same	881

Articles.		June 1, 1888, to May 31, 1889.	
		Quantity.	Value.
Outward freight.			
Cotton	bales	255	$12,750
Cotton seed	sacks	18,975	284,625
Hides		1,615	1,615
Alligator hides		2,562	3,202
Lumber	feet	25,140,000	377,100
Shingles		7,252,000	21,756
Miscellaneous freight		187	3,740
Total		.....	704,788
Inward freight.			
Flour	barrels	5,537	22,148
Meal	do	5,983	11,966
Sugar	do	1,280	23,040
Molasses	do	1,000	8,000
Rice	do	232	754
Coal-oil	cases	3,958	11,874
Oats	sacks	6,011	7,514
Corn	do	12,414	12,414
Bacon	cases	587	17,610
Whisky	barrels	87	4,350
Miscellaneous freight		1,434	28,680
Total		.....	148,350
Outward freight	tons	7,667	704,788
Inward freight	do	4,270	148,350
Total	do	11,937	953,138

Money statement.

July 1, 1889, amount available	$10,000.00
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	23.00
July 1, 1890, balance available	9,977.00
Amount appropriated by act of September 19, 1890	75,000.00
Amount available for fiscal year ending June 30, 1891	84,977.00

T 9.

IMPROVEMENT OF SABINE RIVER, LOUISIANA AND TEXAS.

A survey of the mouth of this river was made in 1871. It had a channel over the bar 3½ feet deep. In 1872–'73 the survey was extended from the mouth to Belgora, Tex. The information obtained did not warrant the expenditure of any money for improvement above Hamilton, Tex., about 247 miles above the mouth, to which point there is 3 feet depth for about three months in each year.

The estimated cost of improvement over this stretch of river by removal of obstructions such as logs, snags, fallen trees, etc., was $18,000.

In June, 1878, Congress appropriated $10,000 for the improvement, with which a channel 6 feet deep, 70 to 100 feet wide, was dredged over the bar at the mouth.

March 3, 1879, Congress appropriated $6,000 more and provided for a resurvey of the river from its mouth to East Hamilton.

After the survey was completed it was deemed advisable to spend this money in improving the river above Orange, and cuts were made from the main river into the narrows and at Dead Bend. Large numbers of sunken logs and snags were removed from the upper part of the narrows enabling vessels of 5 feet draught to get 30 miles above Orange.

In 1880 Congress appropriated $5,000, and in 1881 $7,000 more, for this river. The bar at the mouth had again shoaled. This was redredged in 1881–'82 to a depth of 6 feet, and a channel 100 feet wide was made a little over 1 mile in length, which still remains in fair condition.

In 1882 Congress appropriated $4,000 more for this improvement. As the river was in a sufficiently good condition for the limited commerce which it carried, this money was held for further use.

An examination in May, 1889, showed many snags and some shoal places in the part of the channel known as "The Narrows," and as some $4,000 was available for work, a project was submitted for removing the snags and closing the two "Old River" branches with dams of piles, brush, and earth, to throw all the water into "The Narrows."

This project was approved, the work advertised, and contract was entered into September 20, 1889, with the Sabine Tram Company to complete the work by December 1, 1889, for $3,647.

The smaller dam was successfully built, and most of the piles driven for the larger one, when a sudden rise in the river washed out many of them. The water continued rising, and remained so high that satisfactory work could not be done, so the contract was extended to October 30, 1890, by the Chief of Engineers, and work will be resumed as soon as the water falls.

The United States suffers no loss, as payment is not to be made until all the work contracted for is completed and accepted.

The contractor, under date of June 2, states that the completed dam is standing all right, but that it has settled, and will have to be built some higher when work is resumed.

This was, of course, to be expected from the manner of its construction.

The contractor also states that about one-half the piling driven in the larger branch still remains.

Money statement.

July 1, 1889, amount available	$4,517.66
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	578.05
July 1, 1890, balance available	3,939.61

T 10.

IMPROVEMENT OF NECHES RIVER.

The river was surveyed in 1872 and 1873, and resurveyed from Bevilsport to its mouth. The following are the appropriations made for the river:

June 18, 1878	$8,000
March 3, 1879	5,000
June 14, 1880	5,000
March 3, 1881	3,000
August 2, 1882	5,000
July 5, 1884	7,000
Total	33,000

The project contemplated dredging a channel over the bar at the mouth of the river and the removal of obstructions from the river between Bevilsport and Yellow Bluff.

The bar at the mouth was dredged in 1880, and a channel 5 feet deep and 30 to 60 feet wide was obtained.

In 1882 the obstructions between Yellow Bluff and Bevilsport were removed. The original estimated cost for making these improvements was, for work at the mouth of the river $26,318.05, and for up river $15,000; a total of $41,318.05.

The bar at the mouth of the river again shoals, until at extreme low water there was a depth of about 3 feet over it. There is very little commerce passing in and out of the river, but as the bar at this place was the shoalest obstruction between the Gulf and Beaumont, Tex., and the money was available for dredging the bar, it was thought advisable to re-open this channel.

For this purpose the Government dredge, which had completed work at the head of Calcasieu Pass, was placed in good repair, and sent over to the mouth of the river in December, 1888. By the 1st of May the dredge had removed 55,842 cubic yards and completed a 5-foot channel across the bar, following the old one, of which traces still remained.

The total amount thus far spent upon the river is $28,832.16, leaving still unexpended $4,167.84.

The dredged channel can not be expected to be permanent in such a broad and shallow body of water as Sabine Pass, but will probably serve all the necessities of the commerce using it for several years.

No appropriation is required for the fiscal year ending June 30, 1892.

From June 1, 1888, to May 31, 1890, $150,000,000 feet of logs were driven down the Neches River, valued at $900,000.

Money statement.

July 1, 1889, amount available	$4,167.84
July 1, 1890, balance available	4,167.84

T 11.

IMPROVEMENT OF SABINE PASS, TEXAS.

The object of the improvement is to obtain deep water over the bar at the entrance to the harbor. In 1878 and 1880 channels from 12 to 16 feet were dredged through the bar, but soon filled up.

In 1882 a project was adopted for improving this entrance by means of two jetties of brush and stone, aided by dredging, if necessary, at a total estimated cost of $3,177,606.50.

Since that time Congress has made the following appropriations for this work:

August, 1882	$150,000
July, 1884	200,000
August, 1886	198,750
August, 1888	250,000
Total	798,750

All the work done has been by contract after due advertisement and actual construction was begun in 1883. With the appropriation of 1882, $150,000, and about the same unexpended balance of former appropriations, material to the amount of 188,552 cubic yards was put in place, operations being confined entirely to the west jetty. With the appropriation of 1884 work was continued on the west jetty and the east jetty commenced. At the close of that contract the east jetty had been built to the level of mean high water for a length of 10,840 feet, or a little over 2 miles, and the west jetty foundation laid to a length of 16,074 feet (3.04 miles), of which 7,270 feet (1.38 miles) was raised to the level of mean high tide.

These partially completed jetties had by June 30, 1886, increased the least depth on the bar to 8 feet at mean low tide where there was originally 6 to 6½ feet. This involved the scouring of a little more than 1,000,000 cubic yards from the bar.

In June, 1886, a cyclone damaged the jetties to the amount of $23,000, mostly confined to the top work.

In October, 1886, proposals were invited for continuing the work with the appropriation made that year, and contract entered into with the lowest bidder, the Louisiana Jetty and Lightering Company, of New Orleans.

On the 12th of that month occurred the tidal wave that swept away nearly the entire town of Sabine Pass, and which, although it affected the jetties but slightly, damaged the contractors' plant to such an extent they were unable to resume work until January, 1887.

Under that contract work was confined to the east jetty, and at its conclusion the foundation course was 14,410 feet in length, of which 14,100 feet was raised to high-tide level.

After the close of the contract, in August, 1887, a survey was made, and showed a least channel depth of 8.3 feet. A comparison of this survey with that of January, 1887, showed that the inside 9-foot curve had moved 3,000 feet seaward in the interval, or to within 2,000 feet of the corresponding outside curve, together with considerable filling in behind (outside) the east jetty.

By act of Congress, August 11, 1888, $250,000 more became available for the work. Early in September the work was advertised, bids opened on the 9th of October, and contract duly entered into with the lowest bidder, the Louisiana Jetty and Lightering Company.

To ascertain the condition of the work and the changes, if any, that had occurred during the preceding year, a new survey was made in September, 1888, and a comparison of this with the one made in August, 1887, showed the crest of the east jetty out to 8,000 feet to be about 1 foot lower, and from this point to the outer end about 2½ feet lower than at the close of work in August, 1887. The crest of the west jetty had

not perceptibly changed except over the outer 1,200 or 1,500 feet, and there it averaged about 1 foot lower than it was one year before.

There was a least channel depth of 9 feet on the bar at mean low tide, the 9-foot curves inside and outside having joined, forming a channel whose least width was something over 200 feet.

This comparison showed also a general and considerable deepening immediately between and in front of the jetties, extending about 2,500 feet beyond the line joining their ends, or out to the 12-foot curve, the position of which had changed little.

The channel, as on the preceding survey, crossed from near the west jetty at 6,500 feet to very near the outer end of the east jetty, the least water being at the point of departure from west jetty.

To prevent the filling of the channel by the movement of material along the bottom from east to west it was decided to put most of the work on the east jetty, raising it to about 1 foot above high water to near the extremity of the new work to be put in, work upon the west jetty to be confined to raising it 1 foot above high water to a point near the wreck *Clifton*, about 7,500 feet from the shore end and somewhat outside the point where the channel leaves the west jetty to cross over.

Under this contract up to the close of the last fiscal year (June 30, 1889) the foundation of east jetty had been extended about 2,300 feet to a total length of 16,647 feet, or a little more than 3 15 miles. The foundation of this extension has a uniform width of 60 feet, except the 240 feet at the outer end, which is 112 feet wide to receive an experimental superstructure of rubble-stone faced with blocks of stone weighing from 1 to 3 tons and carried to 6 feet above low water.

This experimental section was recommended by the Division Engineer and approved by the Chief of Engineers. Four gas-pipes were attached to the bottoms of the mats in this section in order that observations might be taken to determine how much it settles into the bottom and how much the mats compress.

This contract, a little less than two-thirds completed on June 30, 1889, was finally closed in December last.

During the year the following material was placed in the work: 7,458 cubic yards of brush, 15,611 gross tons of sandstone riprap, 3,265 gross tons of granite riprap, and 9,378 gross tons of sandstone in large blocks; making a total for the whole contract of 59,634 cubic yards of brush and 42,560 gross tons of stone, or a total volume of about 100,000 cubic yards at a cost of $2.35 per yard.

The annual repor tof Mr. A. C. Bell, assistant engineer in local charge, is herewith, and reference to it is respectfully made for details.

The present total length of the east jetty is 17,100 feet ($3\frac{1}{4}$ miles), of which the outer 450 feet consists of foundation work only to prevent scour around the end of the rock section; of this the crest of the 16,450 feet inside of the rock section averages a little more than 1 foot below mean high tide, or is at about the level of mean low tide.

The experimental rock section settled considerably, but was built up and added to until at the close of work it stood $4\frac{1}{2}$ feet above mean low water, the total settlement being about 3 feet, probably nearly all into the mud, as the foundation mats were only made about 2 feet in thickness and could hardly have compressed more than one-half foot; this point, however, was not definitely decided, as the pipes put in to determine it were knocked down and had to be replaced by a diver who found the water so muddy he could see nothing and was obliged to work entirely by feeling.

The present total length of the west jetty is 9,500 feet, its outer ex-

tremity being abreast of 13,000 feet on the east jetty; of this length the crest of a little over 7,000 feet averages slightly above mean high water and the remaining 2,500 feet at the same level as a year ago; that is, from $5\frac{1}{2}$ to 8 feet lower.

In December a survey was made of the entire pass, and extended to a depth of 30 feet in the Gulf. A comparison of this with the survey of the pass proper, made before beginning work on the present project, shows light changes from Sabine Lake down to the gorge, or the line from the light-house to old quarantine; from this line out comparison with the survey of September, 1888, shows that the deepest water of the gorge has moved away from the Texas shore slightly, so it is now a little nearer the middle of the channel; the inside 24 feet and 18 feet curves have not changed perceptibly, but that of 15 feet has moved out about 800 feet in a narrow loop pointing to the eastward diagonally across the channel, and the 12-foot curve has advanced 1,700 feet in a narrow loop nearly parallel to the direction of the jetties.

The 1888 survey shows a distance of 5,500 feet separating the inner and outer 10-foot curves with a 9-foot channel only 200 feet in width at the narrowest part; during the year the 10-foot curves have joined, giving a 10-foot channel whose least width is about 100 feet in two places, aggregating 600 feet in length, the intervening 700 feet being 300 feet in width, while both inside and outside this reach it broadens to a width of over 800 feet.

At the narrowest part of the channel soundings of not less than 9.5 feet are found over a width of more than 1,000 feet and soundings of not less than 9 feet over a width of 1,900 feet, showing how slight is the angle of repose of the material upon the surface of this bar, if indeed a slope of 1 in 2,000 deserves such a name.

In front of the mouth of the jetties and outside the bar the 12 feet curve has moved outward an average of 300 feet, the net result being that the inner and outer 12 feet curves are 1,400 feet nearer together than a year ago, and are now about 11,000 feet apart; the 15-feet curve has moved out an average of 200 feet, or the inner and outer 15-feet curves are now 15,000 feet apart instead of nearly 15,600 feet, as last year; the 18-feet curve has advanced 600 feet, while the 24 feet curve shows practically no change of position.

Between the jetties, out to a point abreast of 7,000 feet on east jetty, there has been little change; from there out to abreast of 14,500 feet on east jetty there has been a deepening averaging at least three-fourths foot over the entire area, 7,000 feet in length by 2,300 feet in average breadth between the jetties, or about 450,000 cubic yards of material has been moved; of this the bulk seems to have been deposited quite uniformly to the westward of and near the line of the west jetty, while the balance has stopped in front of the mouth of the jetties, as shown by the advance of the 12, 15, and 18-feet curves.

The year's experience seems to show that riprap of sandstone weighing from 133 to 142 pounds per cubic foot solid is too light for the part of the work at and above low water, although for the submerged work it answers well and is much cheaper than granite.

How this same sandstone in large blocks will keep its place will probably be decided by the 200-foot experimental rock section now in place.

If future appropriations for this work are no greater than the last it will require ten more of them to complete the estimate. The four already made have been at intervals of two years each; therefore, at this rate it will be twenty years before the amount required to-day will have been appropriated, or the work will have been twenty-seven years

under construction, when for the best results it should have been completed within three years. One million dollars is the amount of money that should be expended on this work in a fiscal year to obtain the best results.

In October, 1889, the shipment of lumber to foreign ports began, and to the 31st of May, 1890, the custom-house records show clearances of vessels aggregating 13,762 registered tons, with cargoes aggregating 11,024,680 feet of lumber and 1,803 bushels of corn.

In addition, there has been some lumber shipped coastwise to domestic ports in small vessels not clearing at the custom-house, and of which it is impossible to get the amount.

Money statement.

July 1, 1889, amount available	$20,488.22
July 1, 1889, amount covered by existing contracts	72,665.35
	93,153.57
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	89,339.54
July 1, 1890, balance available	3,814.03
Amount appropriated by act of September 19, 1890	300,000.00
Amount available for fiscal year ending June 30, 1891	303,814.03
Amount (estimated) required for completion of existing project	1,501,250.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	1,000,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

REPORT OF MR. A. C. BELL, ASSISTANT ENGINEER.

NEW ORLEANS, LA., *June* 30, 1890.

SIR: I have the honor to submit the following report on the improvement of Sabine Pass, Texas, for the year ending June 30, 1890.

The work was a continuation of the contract commenced January 2, 1889, and was completed December 24, 1889.

EAST JETTY.

The foundation course has been extended 453 feet, making a total length of 17,100 feet of foundation mattresses now in place.

A list of the mattresses sunk is here furnished.

Foundation mattresses 36 feet wide, and in a double row, and breaking joint at axis of jetty, between 16,647 to 17,100 feet from shore.

Third tier mattresses 30 feet wide, 16,400 feet from shore.

Fourth tier mattresses 15 feet wide, 14,100 to 14,800 feet from shore.

Riprap over the old work, working out from shore, and raising the work 1 foot above mean high tide, was continued until August 7 when a severe gale started and continued until the 10th.

During this blow six mattresses were washed off the jetty and six more very badly broken up, and a large amount of sandstone covering the top mattresses of both jetties was washed off. The riprap over old work was at once discontinued and repairs to the damaged work commenced, by filling the gap left by the mattresses with stone and covering the broken and bare mattresses with a thick layer of sandstone.

The 200 feet of experimental rock jetty, with mattress foundation 112 feet wide, 240 feet long, and 2 feet thickness of brush; superstructure of sandstone, 72 feet base, 12 feet crown, and 15 feet in height, was completed, and contains the following amount of material: 2,345 cubic yards of brush mattresses, 3,562 tons of sandstone, 1,750 tons block sandstone, 1 to 3 tons each in weight.

At the close of the work the total amount of settlement into the mud of the foundation mattresses of this section was 3 feet.

The cost per cubic yard, at contract prices, of jetty raised and built, has been prepared, and is given as follows:

Granite riprap, 600 feet, raised 2 feet over old work, or 15 feet above mean high tide, $4.73.

Sandstone riprap, 3,000 feet, raised from 1 to 2 feet over old work, or to mean high tide, $3.37.

Top mattress work, mattresses and stone, 4,000 feet over old work, or to mean high tide, $2.30.

Proportion of stone to brush, 1 ton to 1.6 cubic yards.

New work, 2,500 feet, layers of mattresses and stone (base 60 feet, crown 24 feet, height 12 feet), four tiers in height or to mean high tide, $2.16.

Proportion of stone to brush 1 ton to 2 cubic yards.

Foundation extension, 400 feet, mattresses and stone (one tier 72 feet in width, 5 feet in height), or 9 feet below mean high tide, $1.88.

Proportion of stone to brush 1 ton to 4 cubic yards.

Eperimental rock jetty, 200 feet, mattress foundation and stone superstructure of dimensions previously mentioned, raised 5 feet above mean high tide, $3.86.

WEST JETTY.

Work on this jetty has been confined to the extension of top work with mattresses and stone.

Fourth-tier mattresses, 18 feet wide, 5,200 feet to 7,000 feet from shore, $18.

The length of the foundation course is 9,500 feet.

Two classes of work were put on this jetty, and the cost per cubic yard is as follows:

Sandstone riprap, 1,500 feet, raised 2 feet over old work, or 1 foot above mean high tide, $3.37.

Top mattress work, 4,900 feet, mattresses and stone, raised 4 feet over old work, or one-half foot above mean high tide, $2.27.

Proportion of stone to brush 1 ton to 1.4 cubic yards.

From July 1, 1889, to close of contract, December 24, 1889, 7,458 cubic yards of brush, 15,611 tons of sandstone, 3,265 tons of granite, and 15,378 tons of block sandstone has been placed in both jetties.

Below is shown the total amount of material used in both jetties during the contract:

Brush	cubic yards..	59,634
Sandstone	tons..	34,461
Granite	do....	6,369
Block sandstone	do....	1,750

Taking the actual amount of stone used to sink and cover mattress work the proportion of stone to brush is 1 ton to 2 cubic yards. With the total amount of stone used the proportion is 1 ton to 1.4 cubic yards.

The height of the crest (referred to plane of mean high tide) for different portions of each jetty is appended. Distances are taken from the original of each jetty.

EAST JETTY.

Distance from origin of jetty.	Height of old work September, 1888.	Height of new work raised during contract.	Height of old and new work in December, 1889.
0 foot to 2,700 feet	Mean high tide		0.5 below.
2,700 feet to 3,300 feet	0.5 below	1.5 above	Mean high tide.
3,300 feet to 4,300 feet	0.5 below	1.0 above	1.0 below.
4,300 feet to 8,000 feet	1.0 below		2.0 below.
8,000 feet to 10,000 feet	2.5 below	Mean high tide	1.0 below.
10,000 feet to 14,000 feet	4.0 below	do	1.0 below.
14,000 feet to 16,450 feet		do	1.5 below.
16,450 feet to 16,650 feet		5.0 above	4.5 above.
16,650 feet to 17,100 feet		9 to 15 feet below	11.5 below.

WEST JETTY.

0 foot to 600 feet	Mean high tide		Mean high tide.
600 feet to 2,100 feet	0.5 below	1.0 above	1.0 above.
2,100 feet to 7,000 feet	3.5 below	0.5 above	Mean high tide.
7,000 feet to 9,500 feet	5 to 7 feet below		5.5 to 8 feet below.

Two different qualities of stone (granite and sandstone) having been used in the construction, opportunity was afforded for comparison of the stone as to their suita-

bility for the two classes of work, submerged and top work. Sandstone from its smaller specific gravity and softness is not suitable for top work when exposed to the heavy action of waves. Owing to its light weight in comparison to its bulk it is moved by very moderate waves, and during the action of one severe storm a large amount of sandstone was washed off of the top work, leaving the mattresses exposed. It does not pack and become solid and when compared with granite riprap has a very loose and insecure appearance. In submerged work it is all that can be desired as its large bulk and cheapness allows much more work to be accomplished than with granite. Towards the end of the contract a hard blue sandstone was furnished of good quality and greater specific gravity, but very brittle. This stone might answer for top work, but no pieces less than 150 pounds should be used.

Granite having large specific gravity and excellent packing qualities makes it the best material for top work. Experience has shown that riprap even of granite will not stand above average flood tide.

At the completion of the contract a cluster of four round piles with bark on was driven at the end of foundation mattresses of east jetty and one each at the inner or channel edge of foundation work at intervals of 1,000 feet, starting 5,000 feet from shore.

On line of west jetty a cluster of two piles was placed at the end of foundation work and one each at intervals of 1,000 feet, starting 2,000 feet from shore.

Twenty-seven piles were used in the work to work the inner edge and extreme end of this jetty, thus providing for the safety of vessels entering the bar.

SURVEYS.

During the month of December, 1889, a survey was made of the pass, extending from the shoal water at the head or entrance to the lake to the throat of the pass opposite light tower, 6½ miles in length and an average of one-half mile in width. This was thoroughly sounded, and soundings and contours referred to plane of mean low tide are shown on the accompanying chart. Comparison with the old chart shows no material changes. A gradual caving of the west bank between the town of Sabine Pass and new Quarantine Station is shown.

The regular survey starting at a line joining Light House and Texas bayous and extending out to 30 feet of water beyond the end of jetty walls and embracing the channel or area between the jetties, also that portion on the east of east jetty and west of west jetty likely to be affected by the present works.

The accompanying chart shows the soundings and contours reduced to mean low tide. The 9-foot channel has an average width of 2,000 feet, and at 6,000 feet from shore on line of east jetty extends from jetty wall to jetty wall. The 10-foot channel has cut through the bar and opposite the wreck of Clifton extends the full width of channel from jetty to jetty. At 14,000 feet the 10-foot channel narrows to about 200 feet; this is caused by the formation of a hard crust of sand extending entirely across from wall to wall and has a length of 2,000 feet (14,000 feet from shore).

This deposit has been formed by the shore drift during westerly winds. I has a thickness of 3 or 4 inches, and offers a very strong resistance to the thrust of the iron-shod pole. A slight shoaling is shown at the Gulf end of the jetties amounting to something less than a foot. An advance seaward of the 18-foot curve is also shown, amounting to about 300 feet. No changes have taken place on the east or Gulf side of east jetty, but on the west side of west jetty, owing to the raising of this jetty along its length, a very decided fall has taken place, amounting to 2 or 3 feet. This deposit is of a soft, tenacious mud, and similar in character to that found in the channel and outside the jetty walls, with the exception of the east side of east jetty where numerous areas of sand are to be found, showing that a gradual deposit of sand is taking place on that side.

Cross-sections taken on both jetties at intervals of 1,000 feet of their length show no material change except that attributable to settlement and compression and the addition of material in building up and repairing the walls. From careful probings it can be safely stated that none of the stone washed off the top work was lost, but has been rolled over and deposited on the bottom mattresses.

A good 10-foot channel of ample width is shown on the chart, and has been used by the mill men of east Texas and west Louisiana in shipping large cargoes of lumber to various points in Mexico and Central America. An attempt was made with the tug used for towing the vessels (while not otherwise employed) to deepen the channel by dragging a harrow during the ebb-tide, but beyond keeping open the 10-foot channel through the sand area (previously mentioned), which might otherwise have filled up, no material deepening could be ascertained.

Very respectfully your obedient servant,

A. C. BELL,
Assistant Engineer.

Capt. W. L. FISK,
Corps of Engineers, U. S. A.

ARCHIVE



902 b

Cross Sections of East and West Jetties, Sabine Pass, Texas.

MADE UNDER THE DIRECTION OF

Captain W. L. FISK, Corps of Engrs, U. S. A.

by

A. C. Bell, Assistant Engineer,

DECEMBER, 1889.

HORIZONTAL SCALE = 1:500

VERTICAL SCALE = 1:100

EAST JETTY.

GULF — MEAN LOW TIDE — PASS.

STATION 2000.

STATION 2000.

STATION 3000.

STATION 4000.

STATION 5000.

STATION 6000.

STATION 7000.

STATION 8000.

STATION 9000.

STATION 10000.

STATION 11000.

STATION 12000.

STATION 13000.

STATION 14000.

STATION 15000.

STATION 16000.

STATION 17000.

STATION 17550.

WEST JETTY.

PASS. — MEAN LOW TIDE — GULF.

STATION 2000.

STATION 3000.

STATION 3060.

STATION 4000.

STATION 5000.

STATION 6000.

STATION 7000.

STATION 8000.

STATION 9000.

Photo-Lith. by A. HOEN & CO., Balto., Md.

COMPARATIVE
CROSS SECTIONS OF EAST AND WEST JETTIES, SABINE PASS, TEXAS

MADE UNDER THE DIRECTION OF

Captain W. L. FISK, Corps of Engrs, U. S. A.

by

A. C. Boyd, Assistant Engineer

SEPTEMBER 1889

HORIZONTAL SCALE = 1 100

VERTICAL SCALE = 20

Note. Cross sections in new takes, March, 1889.

EAST JETTY.

GULF MEAN LOW TIDE STATION 1000 OF THE GULF. PASS.

STATION 2000.

STATION 3000.

STATION 4000.

STATION 5000.

STATION 6000.

STATION 7000.

STATION 8000.

STATION 9000.

STATION 10000.

STATION 11000.

STATION 12000.

STATION 13000.

STATION 14000.

STATION 15000.

STATION 16000.

STATION 17000.

STATION 17300.

WEST JETTY.

PASS. MEAN LOW TIDE STATION 1000. OF THE GULF. GULF

STATION 2000.

STATION 3000.

STATION 4000.

STATION 5000.

STATION 6000.

STATION 7000.

STATION 8000.

STATION 9000.

Photo-Lith U.S. ENG. & CO. Balto. Md.

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APPENDIX U.

SECURING MOUTH OF BAYOU PLAQUEMINE, LOUISIANA, FROM FURTHER CAVING.

REPORT OF CAPTAIN DAN C. KINGMAN, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1890.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., July 7, 1890.

GENERAL: I have the honor to transmit herewith my annual report for work of improving Bayou Plaquemine, La., for the fiscal year ending June 30, 1890.

Very respectfully, your obedient servant,

DAN C. KINGMAN,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

IMPROVEMENT OF BAYOU PLAQUEMINE, LOUISIANA.

The river and harbor act of August 11, 1888, appropriated $100,000 for securing a navigable channel 60 feet wide and 6 feet in depth from deep water up to the Plaquemine Dike, and for securing the mouth of the bayou from further caving. This work was not placed under the Mississippi River Commission, and owing to the fact that this was the first appropriation for this work there was, of course, no plant available for the construction of the required bank protection at the mouth of the bayou. As the Mississippi River is very deep at this point a large and expensive plant was absolutely necessary for the work—a plant that would cost a sum equal to or greater than the entire appropriation. For this reason so much of the work as related to the securing the mouth of the bayou from further caving was turned over to me for execution with the understanding that I should use so much of the plant belonging to the improvement of the Mississippi River as might be available and necessary for the work, and $75,000 of the appropriation was allotted for the work. Of this sum $1,000 had already been expended by Captain Fisk for preliminary examinations and surveys, the results of which were furnished me, and $170 were reserved for use in the office of the Chief of Engineers.

The following project was accordingly prepared and approved:

It is proposed to construct four large spur-dikes at the points indicated upon the accompanying drawing. The subaqueous portions will be constructed of willow cribs and will be in all respects like the spurs built in New Orleans Harbor, except that the foot mat will not be woven, but will be built up like the mats used in the Atchafalaya sills. It will be 2 feet thick. From the main levee an earthen spur will extend out to the crest of the bank. The top of this portion will be horizontal, and the same height as the main levee, so that the water can never flow over it. It will be well sodded. From the crest of the bank the earthern spur will extend down with a height of about 10 feet until it connects with the subaqueous portion of the dike. This sloping part will be covered with a layer, 9 inches thick, of good gravel, upon which a stone pavement, 9 inches thick, will be laid. This stone and gravel covering will extend 20 feet above the toe of the up-stream slope of the spur, and 50 feet below that of the down-stream slope. The earthern portion of the spur will have a crown-width of 10 feet and side-slopes of 1 on 3.

This work was not confided to me till the 20th of May, 1889. The only outfit that I had that was suitable for this work was that pertaining to the rectification of the Red and Atchafalaya rivers. And I thought, in the early part of the season, that I could finish all the work that I had means to do in the Atchafalaya by the end of September, and this would enable me to move down to Plaquemine early in October, or in time to finish the work in one year. But owing to the high stage of water that prevailed during the summer months I could not complete the season's work in the Atchafalaya until about the 10th of November. I was then in doubt as to the advisability of beginning work at Plaquemine at all that season, but as the money had been available for more than a year and nothing had been done, and as it would have been necessary, in case the work was not done then, to wait perhaps a year longer, and then the plant might be required for the work to which it belonged, and finally as the people interested were naturally impatient to see something accomplished, I decided to go ahead with the work as long as the stage of the river would allow. As everything, even the rock, had to be brought from Simmesport, a hundred miles away, it took some time to effect the installation, but by the 20th of November everything was on the ground and the work was begun. It was carried on in spite of many obstacles, rising river, swift current, extraordinary depth of water, heavy drift, dense and persistent fogs, till about the middle of January, 1890, when on account of the high stage of the river it was necessary to discontinue the work and return the fleet to laying-up quarters at Simmesport. Two spurs were constructed, Nos. 1 and 2.

The method of construction of the spurs was as described in the approved project. The foundation mattress of each spur was built up of layers of willow brush at right angles to each other to a thickness of 2 feet and clamped by sawed scantling in pairs, as shown in the accompanying photograph; and the mattress was firmly compressed in the manner there indicated. The mats were made in each case at least 20 feet longer than the longest crib, and they were given such a width as to enable them when in place to extend at least 20 feet farther up the stream than the widest crib and 60 feet further down-stream. The cribs were similar to the mats in construction, but they were made 6 feet in thickness, and heavier scantling was used for clamping-pieces. The willow brush was so placed around the stanchions as to form cells or pockets to receive and hold the ballast when the cribs were sunk. To save rock, of which only a limited quantity was available, the pockets of the lower cribs of the two spurs constructed were partly filled with coarse gravel in sacks. There is always a great deal more rock required to sink a crib than would finally be necessary to hold it in its place on the bottom. The cribs when first built have a good deal of

free buoyancy and float very high in the water, but after a time the silt collects in the crib and finally causes it to sink. A small experimental crib built of rather dry willow remained afloat for ninety days and then settled to the bottom. At the bed of the river, where the run of silt is much greater, a crib must soon become solidly filled with sand so that it would be perfectly secure even if all the rock was removed from it. In sinking the mattresses and wide cribs they were held by the up-stream edge only. Two lines of barges were used, extending out into the river in a direction parallel to the axis of the proposed spur. The lower line was a little above the line upon which the up-stream edge of the mat or crib was to be sunk. The other line of barges was placed about 500 feet farther up-stream. The barges were lashed together end to end, and the upper line was held in place by a number of steel-wire cables leading diagonally up-stream and fastened to secure anchorages in the bank. The cable to the outer end of the barges was over 1,000 feet in length. The lower barges were held also by wire cables leading straight down from the upper barges. The upper and lower lines of barges were called, respectively, "mooring" and "lowering" barges. The mat or crib was secured to the lowering barges by a set of lines called "lowering lines." These lines were of 3-inch manilla rope, and the end of each was passed under a crib-frame and brought up so that the lines were double and the frame was in the bight. By this arrangement, when the crib was in place on the bottom one end of the line could be cast loose and the line hauled in and recovered. Each lowering line was given a single turn around a timber-head and then led away and secured at a proper distance to a single cable called a messenger, which extended the length of the barges and passed to a capstan at each end. In this way as the messenger was drawn from the in-shore to the outer capstan each lowering line would render an equal amount around its timber-head, and thus an equal strain would be preserved on them all and the mat or crib would be held in a horizontal position till it reached the bottom. To keep the mat from swinging down stream as the lowering lines were slacked away, another set of lines (steel-wire cables) were led from the mooring barges, passing under the lowering barges and fastened to the head of thematat. These lines, which were called "toggle lines," were placed parallel to the current, and this explains the necessity for the mooring barges, for if the toggle lines led to the shore they would produce a strain that would tend to double up the crib or mat. The toggle lines had eyes at the end and were secured to the crib by thrusting this eye in among the willows and afterwards passing a long, iron pin through it. When the crib was on the bottom these pins were withdrawn by lines which were attached to them for this purpose, and the toggle lines could then be recovered. The mat or crib then being in position with all of these lines attached it was loaded until its buoyancy was completely overcome, and it was kept from sinking by the lowering lines at its head and the force of the current running under it, which held it out like a flag in the wind. Additional rock was then thrown on the head so as to produce a good strain on the lowering lines. To determine the exact position of the mat or crib after it sank below the surface of the water, a number of very strong wires were fastened to it along the line which was to be the axis of the spur when constructed. The free ends of these wires were held upon the lowering barges. Everything being ready the messenger line was slowly slacked away. A man was stationed at each timber-head to see that the lowering line rendered freely and promptly around it and the mat sank slowly down, preserving its horizontal position. From time to time

the lowering was stopped and the exact position of the mat with respect to the axis of the spur was determined as follows: Each of the wires before described was taken in succession to a small barge and passed over a sheave at the end of a protecting arm at some distance above the surface of the water, and by a suitable appliance a strain of several hundred pounds was placed upon it, a strain sufficient to draw it perfectly straight. The wire was then made vertical by the aid of a transit instrument on the bank at the root of the spur, the barge being shifted as was necessary to accomplish this purpose. If the mat was found to be off the range its position was corrected by letting out or taking up the corresponding toggle line. In practice the mat was always started down a little above the required range, for it was much easier to slack away the toggle line than to haul the mat up-stream against the current; for when the current was strong the strain on the toggle lines was very great, so that even in slackening away on a line a stream of sparks flew from the iron timber-head as the steel cable rendered around it. When the mat reached the bottom a stone barge was floated over it and an additional amount of ballast was thrown upon it. The lowering lines were then removed, but the toggle lines were allowed to remain attached over night to allow the mat to become fixed in its place and prevent its shifting down-stream.

I have given this description of the manner of constructing a spur in detail, because I do not find it in previous reports and because I believe the spur-dikes afford the safest and surest as well as the cheapest method of protecting the caving banks of the Mississippi River.

The two spurs were subjected very soon after their completion to an almost unprecedented flood. No survey has yet been made to determine their present condition, but as far as can be seen by an inspection they have suffered no material injury. That portion of the earthen spur which was not protected by paving was somewhat injured by wave-wash. This was to have been expected, because the sod had not become sufficiently strong to afford an adequate protection. On Spur No. 1 the injury was trifling; a few dollars will fully repair it. On No. 2 it is greater, because the pavement was not carried up quite high enough, owing to the lack of stone, and the earth was cut away above the pavement. It will cost perhaps $100 to properly repair this one. There has been no caving of the bank in the vicinity of the spurs since they have been constructed; but there has been some loss of bank at a point about 2,000 feet below them and quite beyond their influence.

The cost of these two spurs exceeded the estimated cost by nearly 15 per cent. This was partly due to the fact that but two were constructed and the entire cost of moving the plant from Simmesport and back had to be borne by them, and partly to the extraordinary measures that had to be adopted to protect the work while in construction from rafts and drift, and to handle the large cribs and mattresses in such deep water and in so strong a current.

As stated in my last annual report, no estimate can be given of the amount required for the completion of this improvement, because no general project has yet been prepared The caving bend is a very long one and comparative surveys would be necessary to determine the rate of caving in order to find out the places where protection would be required. As no work has been done here before, this bend has not been under close observation. I think it is a question for Congress and the Mississippi River Commission to decide whether this entire bend is to be held in its present form or not.

As the work of improving Bayou Plaquemine is in the charge of

another officer it is presumed that he will furnished the required commercial statistics, and none are given here.

The report of United States engineer, W. G. Price, who was in local charge of the work, and which contains much information in regard to it, is transmitted herewith.

NOTE.—Money statement for this work will be found attached to report on improvement of Bayou Plaquemine, Louisiana, Appendix T 6.

REPORT OF MR. W. G. PRICE, ASSISTANT ENGINEER.

JUNE 30, 1890.

SIR: I have the honor to submit the following report of the construction of two submerged spurs at Plaquemine, La.:

The Red and Atchafalaya plant was used for this work.

On November 11, 1889, Assistant Engineer John Ewens was sent to Plaquemine to construct floating crib-ways which were needed in addition to the floating mat-ways used on the Atchafalaya. The steamer *General Newton* began moving plant to Plaquemine November 12, 1889. A quarter-boat and force of men were left at Profit's Island to cut willows. The whole plant arrived November 19, and work was begun. The dredge *Pah-Ute* was taken to head of Profit's Island November 23 to dig gravel for use in the work.

These spurs are similar to those which have been built in New Orleans Harbor, except that a crib-mat 2 feet thick, same form as used in the Atchafalaya, was used instead of a woven mat; and the pine frames in cribs extended across the cribs instead of lengthwise of them. The mats and cribs were built from floats made of white pine gunwales covered with 2-inch plank, with 6 by 6 inch timbers spiked down for ways. The float for constructing mats was 85 by 66 feet, with ways parallel to the short side. The frames were constructed on the float and were moved into position in the mat as fast as the willows could be filled in. Two by 4 inch lumber was used for the frames except the last frame in each mat was made of 3 by 6 inch lumber for a head-block, and the mats were compressed at each upright with a force of 2,000 pounds. The cribs were constructed in precisely the same way on a float 60 by 66 feet, and 3 by 6 inch timber was used for frames. They were compressed at each upright with a force of 6,000 pounds. An instrument for compressing such mats and cribs was invented at Simmesport in 1887 and does the work very cheaply. The mats were built 75 feet wide with a length equal to the width of the sill of the spur; and then enough mats were wired together side and side to make the length of the spur. The cribs were 6 feet thick and were sunk on top of each other, each successive crib being longer and narrower and each crib being of such a length that when finished the crest of the spur would approximate a straight line. The crib work extended up to low-water mark, and above that point the spur was built of earth covered with gravel and paved with rock. A spur-levee connected the work with the main levee. The method of sinking was the same as has been in use in New Orleans Harbor except that the lower line of lowering barges was used only in sinking the top crib. Two lines of barges were used, the lower line being at the upper edge of the mat or crib to be sunk, and the upper line being 450 feet up-stream. In the upper line were 4 barges placed end to end extending 424 feet out from the bank, and were supported by 4 cast-steel wire ropes 1 inch in diameter. In the lower line were 5 barges extending out in the river 620 feet. They were supported from the upper line with three-fourths-inch cast steel ropes. The sinking ropes which supported the mats and cribs while they were being lowered to the bottom led from the upper line of barges and were five-eighths and three-fourths inch cast steel. The upper line of barges were needed to give the sinking ropes the proper lead. As many as fourteen of these ropes were required to hold one crib against the current. The toggles were 2-inch round iron, but were not strong enough as they were badly bent.

The strong current, fogs, heavy drift, and waves of passing boats made the work of sinking very difficult. The velocity of the current at one time when a crib was being sunk was 5½ feet per second, and the pressure against a board 1 foot square with the upper edge just at the surface was 32.9 pounds. The mats were ballasted entirely with rock. The cribs were ballasted with gravel in sacks, to overcome their buoyancy, and were then heavily loaded with rock before they were lowered to the bottom, all the gravel and rock being placed in the crib pockets. Two spurs were finished January 21, 1890, when the rising river stopped the work. Spur No. 1 was 510 feet long and 20 feet high, with a sill-mat 100 feet wide. Spur No. 2, was 330 feet long and 32 feet high, with a sill-mat 110 feet wide. One-half of the top crib on Spur No.

1 was torn away while sinking it, but it was caught, rebuilt, and successfully sunk in place. The rock was brought from Turnbull's Island where it had been stored for Red and Atchafalaya work. The gravel was dredged and screened from sand at head of Profit's Island and delivered in scows.

Material duse.

Gravel, at $1.13, delivered	cubic yards..	$1,720
Willows, at $1.36, delivered	cords..	3,698
Rock, at $2.69, delivered	tons..	2,721
Lumber, at $12.50, per M., delivered	feet..	126,784

Cost of construction.

Mat, at 2.9 cents per cubic foot	cubic feet..	225,600
Cribs, at 2.2 cents per cubic foot	do...	359,708
Mats and cribs ballasted and sunk in place, at 4.58 cents per cubic foot	do...	585,308
Cubic yards shore embankment and spur-levees, sodded, at 44 cents per cubic yard	cubic yards...	10,829

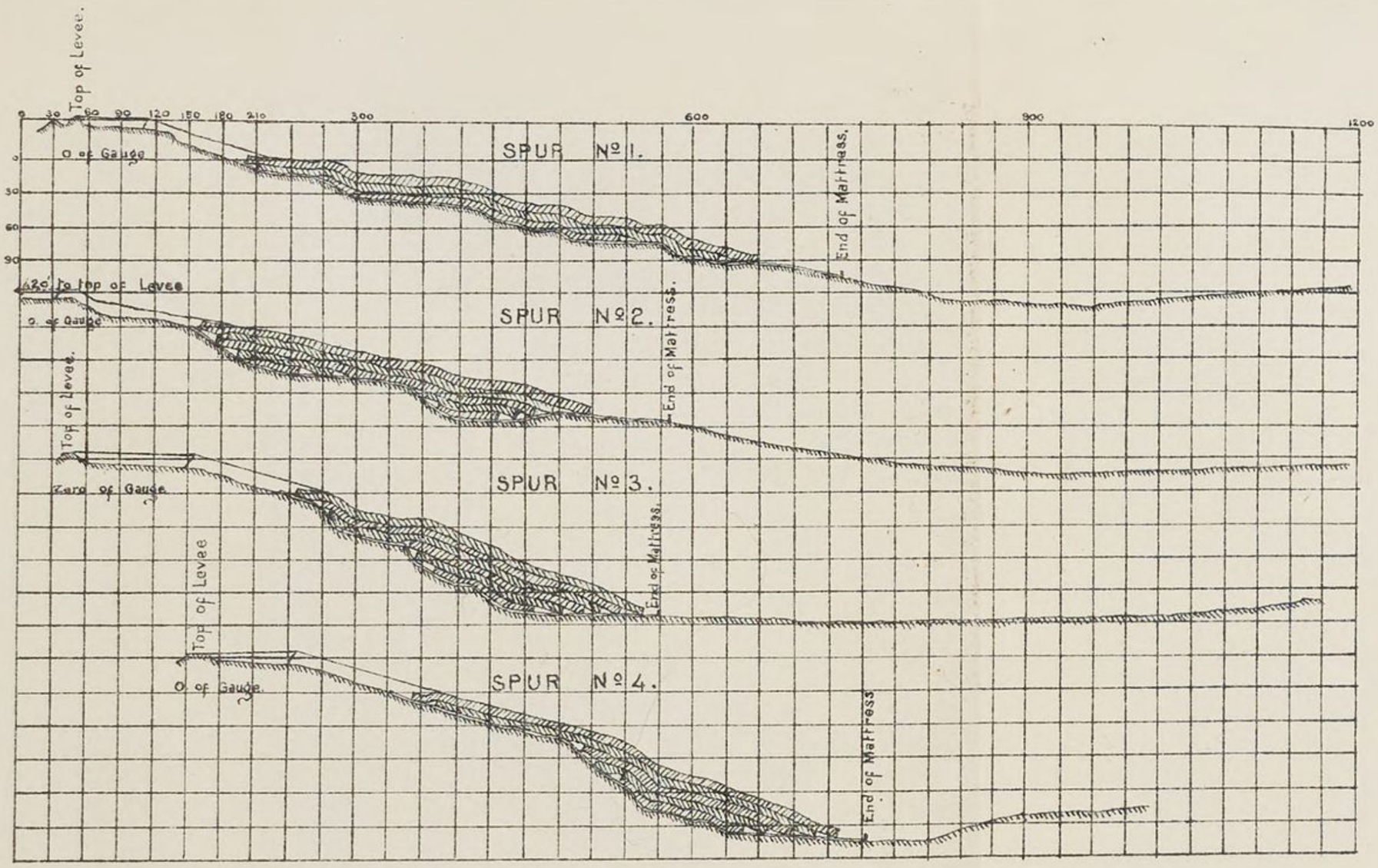
Cost of paving with 684 tons rock and 946 cubic yards gravel, $3,634. All expenses are included except cost of plant and unexpendable material.

The steamer *General Newton* was employed in towing plant to Plaquemine and returning it to Simmesport. She also did some work towing rock and gravel and, when not otherwise employed, was kept at Plaquemine as a reserve force in case of accident, as owing to the swift current and thick fogs, there was constant danger that the plant would be swept away by rafts or steam-boats, and there were some very narrow escapes. The expense of the *Newton* towing plant and while waiting orders at Plaquemine was $3,016.

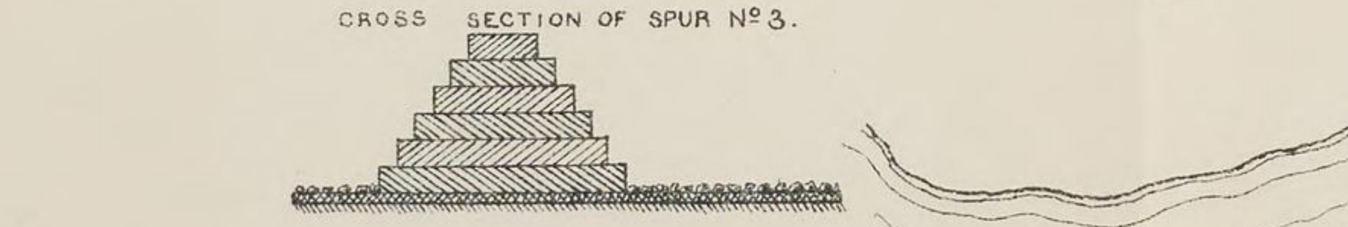
Very respectfully, your obedient servant,

W. G. PRICE,
Assistant Engineer.

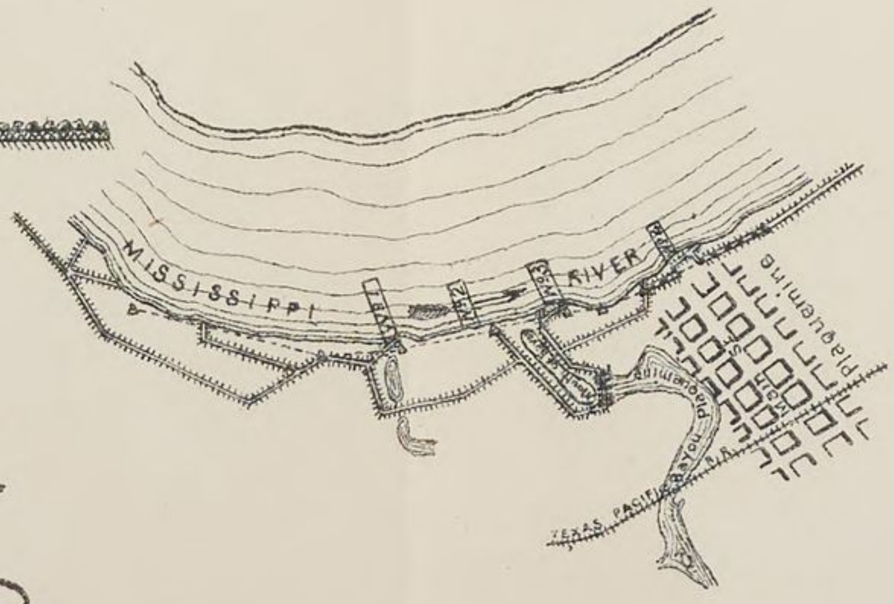
Capt. DAN. C. KINGMAN,
Corps of Engineers, U. S. A.



LONGITUDINAL SECTION OF SPUR Nº 3.



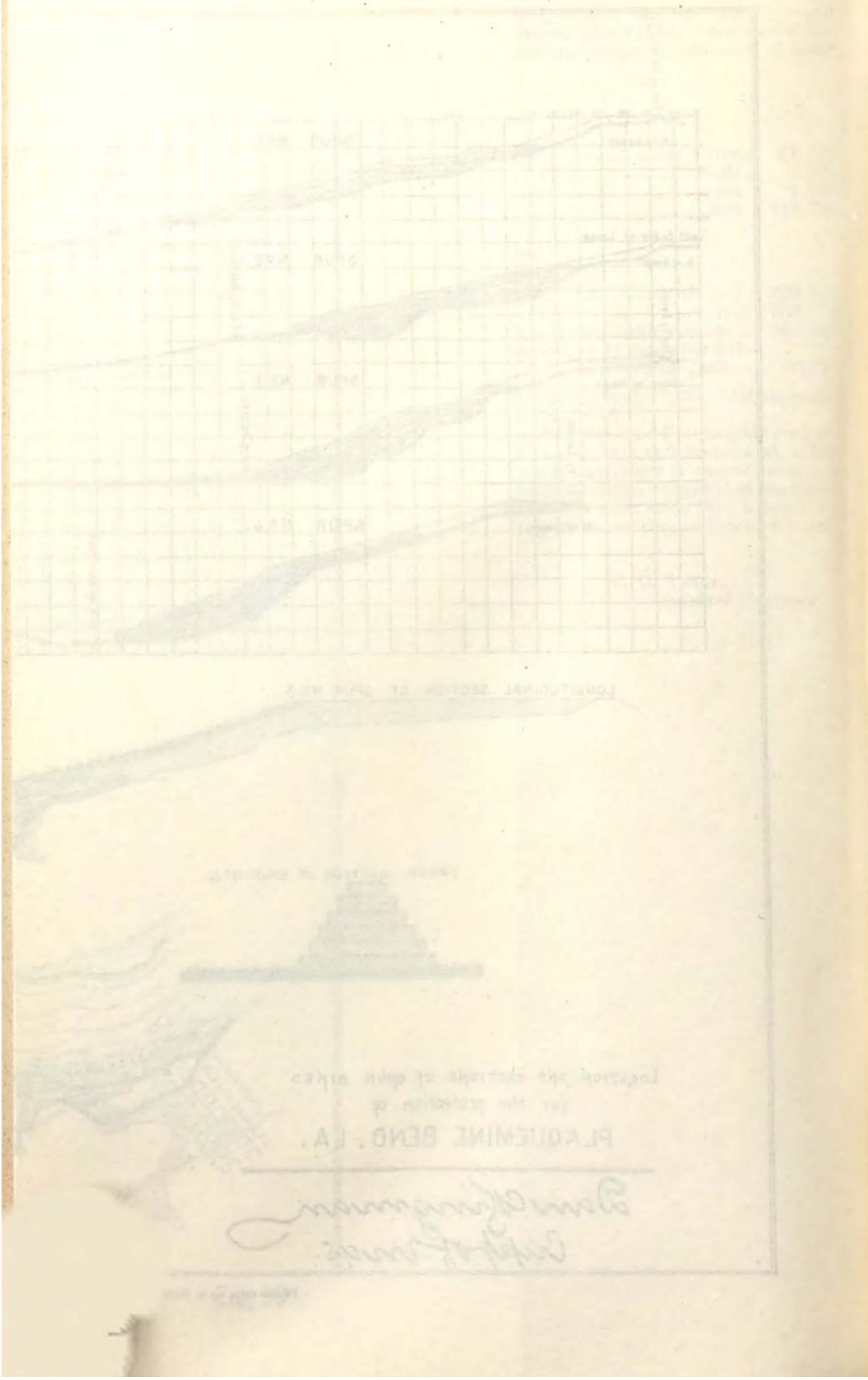
CROSS SECTION OF SPUR Nº 3.



LOCATION AND SECTIONS OF SPUR DIKES
for the protection of
PLAQUEMINE BEND, LA.

Dan C. Kingman
Capt of Engs.

Photo-Lith. by A. HOEN & CO., Balto., Md.

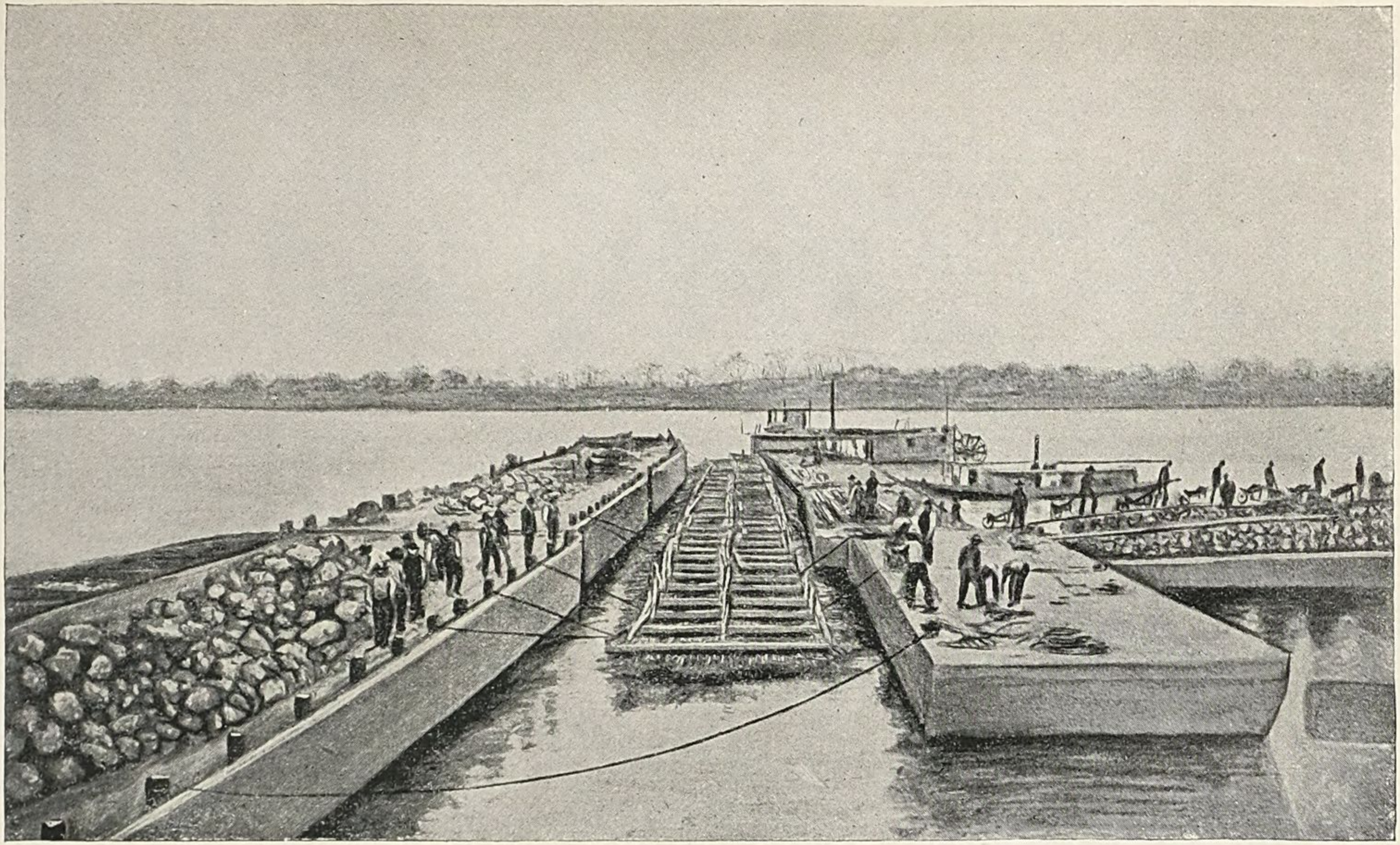




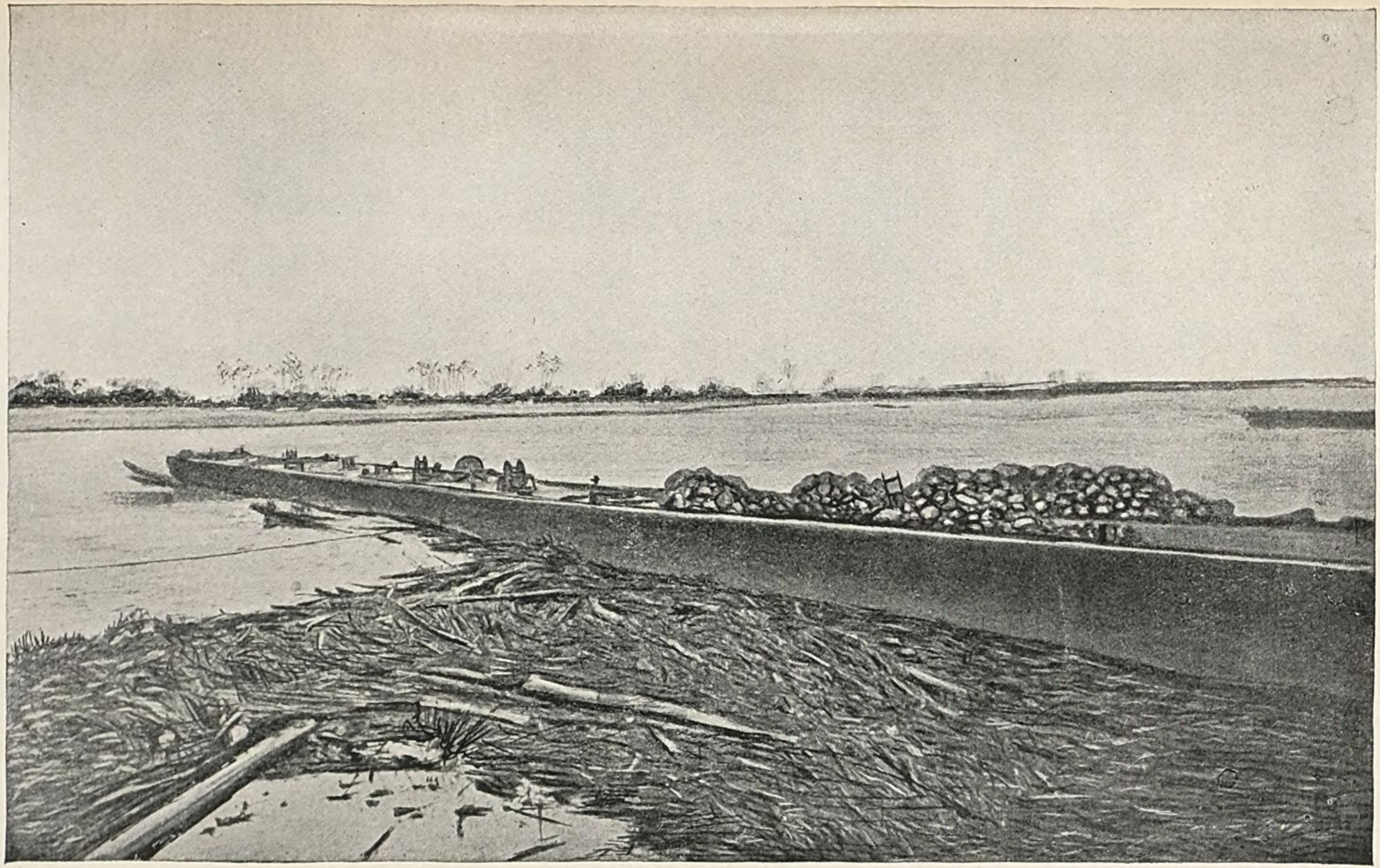
IMPROVING BAYOU PLAQUEMINE: SHOWING THE MANNER OF COMPRESSING A MATTRESS.



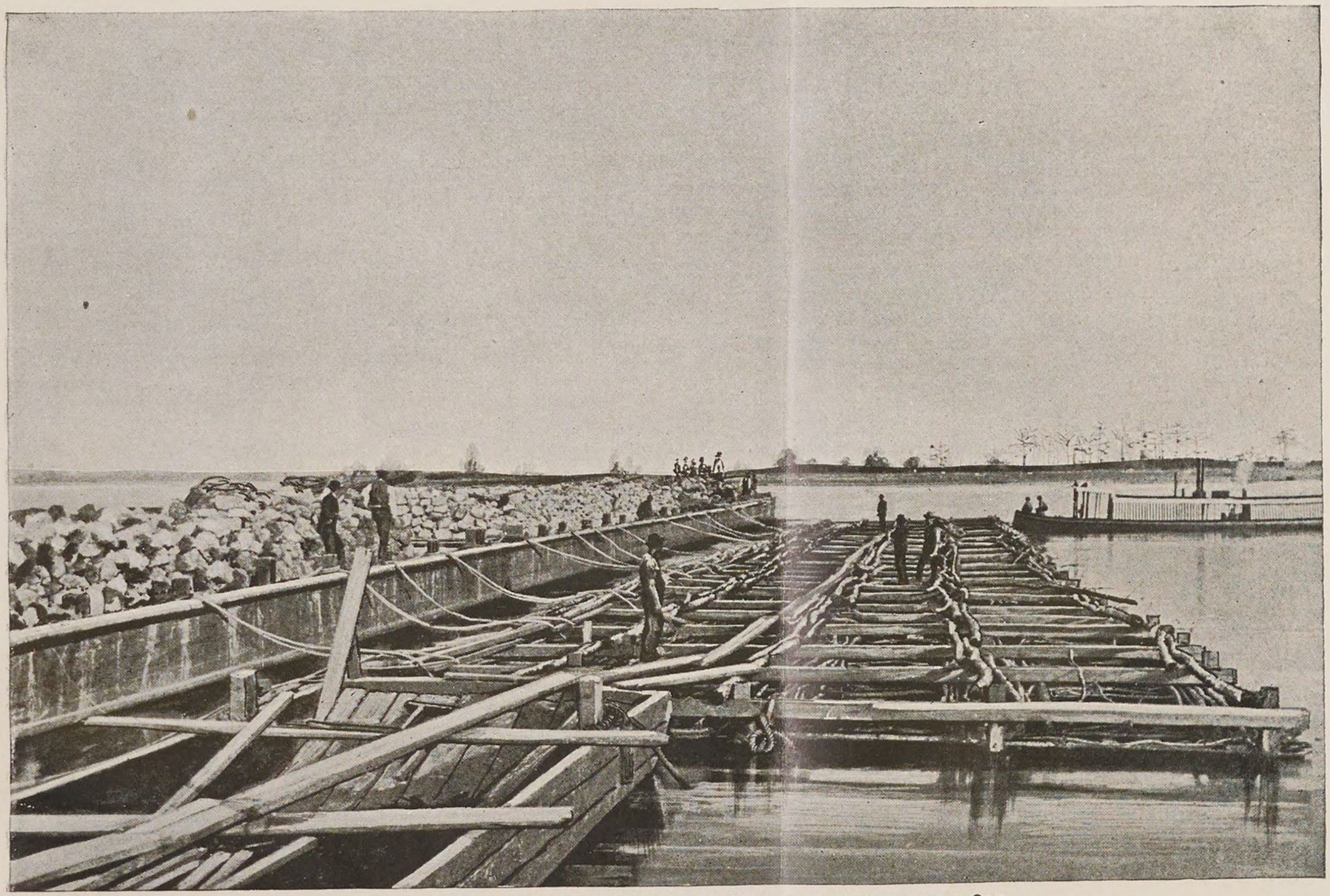
IMPROVING BAYOU PLAQUEMINE: SHOWING THE MANNER OF CONSTRUCTING A CRIB.



IMPROVING BAYOU PLAQUEMINE: SHOWING THE METHOD OF SINKING A NARROW CRIB.



IMPROVING BAYOU PLAQUEMINE: SHOWING THE FORCE OF THE CURRENT AND DRIFT.



IMPROVING BAYOU PLAQUEMINE: SHOWING THE MANNER OF SINKING A WIDE CRIB.

APPENDIX V.

IMPROVEMENT OF RIVERS AND HARBORS IN THE STATE OF TEXAS.

REPORT OF MAJOR CHARLES J. ALLEN, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1890, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

IMPROVEMENTS.

1. Entrance to Galveston Harbor, Texas.
2. Ship-channel in Galveston Bay, Texas.
3. Trinity River, Texas.
4. Buffalo Bayou, Texas.
5. Aransas Pass and Bay, up to Rockport and Corpus Christi, Texas.
6. Harbor at Brazos Santiago, Texas.

EXAMINATION.

7. Removal of bar at mouth of Cedar Bayou, where it empties into Galveston Bay, Texas.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., July 7, 1890.

GENERAL: I have the honor to transmit herewith the annual reports for the works under my charge for the fiscal year ending June 30, 1890.

Very respectfully, your obedient servant,

CHARLES J. ALLEN,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

V 1.

IMPROVEMENT OF ENTRANCE TO GALVESTON HARBOR, TEXAS.

The project for this improvement was adopted in 1874, modified in 1880, and again modified in 1886, the object being to deepen the channel so as to admit sea-going vessels of the deepest draught. The project of 1886 embraces the construction of two jetties, to be built to a height of 5 feet above mean low tide, their effect to be supplemented, if found necessary, by dredging.

The natural depth upon the outer bar was 12 feet and upon the inner bar about 13 feet, both at mean low tide. The general plan of the work is shown upon the accompanying map.

At the date of the last Annual Report there had been constructed but not entirely finished 15,200 lineal feet of the south jetty, including what is known as the shore branch, 9,564 feet long, 5,636 linear feet of jetty extending seaward. The total length of railway constructed upon the crest of the jetty, including 2,175 feet in advance of the stone work,

was 17,375 feet. The railway is used for transporting material to be deposited in the jetty.

The effect of the works at the close of the last fiscal year was found in a depth of 13¼ feet upon the outer and 21 feet upon the inner bar, both at mean low tide, and a general reduction in width of the outer bar.

The amount expended to July 1, 1889, was, including outstanding liabilities, $1,967,176.27.

The work of construction continued during the past fiscal year under the contract with A. M. Shannon & Co., dated October 13, 1888. This contract was to have been completed June 30, 1889. It was extended as to time to December 31, 1889; again extended to June 30, 1890; and further extended to August 30, 1890. All additional expense caused to the United States by the extensions to be deducted from the sums due or to become due the contractors.

The work accomplished during the past year has resulted in an extension of the rock-work for 4,000 linear feet, about 1,200 feet of which is not entirely completed. In addition, the rock-work was completed upon 8,559 feet of shore branch, and portions of the old work received more or less repair. The railway trestle has been extended to a point 428 feet beyond the incomplete rock-work. It is expected with funds in hand to further extend the jetty several hundred feet.

The total of rock-work, complete and incomplete, is, to date, 19,200 linear feet.

A full survey of the harbor, including shore-lines, was made in April, May, and June of this year (1890). A complete map of the survey will be forwarded as soon as it can be finished. A map on a scale of $\frac{1}{40000}$ is herewith, containing the contours of this year and last, from which may be noted the principal changes that have occurred during the year.

There has been a deepening of about 1 foot at the shoalest part of the Galveston Channel, and some enlargement of its area, embraced within the 30-foot contour, near its junction with Bolivar Channel. There has been some slight diminution in the width of the area of Bolivar Channel, between the 30-foot contours, west of its junction with Galveston Channel, and also some increase in deep-water area east of that junction.

The 30-foot depth inside of the outer bar has advanced Gulfward about 1,000 feet, the 24-foot depth about 200 feet, the 20-foot depth about 350 feet, and the 18-foot depth about 200 feet, taking the average. The 24-foot area has also been enlarged, mainly on the north side near its outer end. On the Gulf side of the bar, from the jetty northward, the 12-foot contour has advanced about 300 feet, the 18-foot contour about 200 feet, the 20-foot contour about 400 feet, the 24-foot contour about 600 feet, and the 30-foot contour 200 feet.

The distance between the 30-foot contours on the harbor and Gulf sides of the bar has decreased about 800 feet.

In the jetty channel, the width between the 13-foot contours has decreased, but the depth in the jetty channel is, at mean low tide, 13¼ feet. There has been a notable accretion of sand on the south side of the jetty.

The work was under the immediate supervision of Mr. H. C. Ripley, assistant engineer, a copy of whose report, dated July 1, containing details of work and survey, is herewith.

The amount expended during the fiscal year ending June 30, 1889, is $205,935.39.

The tidal observations in Galveston Bay and at the harbor entrance,

inaugurated in 1888, were continued. Eight self-registering tide-gauges were under observation and their records plotted. For a full account of these gauges attention is invited to the report, hereto appended, of Lieutenant Langfitt, Corps of Engineers.

In March last, running a line of precise levels to connect the zeroes of the tide-gauges with each other and with the permanent bench-mark on the Hendley Building at Galveston, was commenced. The season has been one of floods for the rivers discharging into Galveston Bay, so that the work of connecting bench-marks at Galveston with those at Bolivar Point had to be done across Bolivar Gorge. The connection was made, however, and carried to the tide gauge at Hanna's Reef, though under most disadvantageous circumstances of weather. This work of leveling is, therefore, not completed. A more extended account of the leveling is given in the report, herewith, of Mr. Gerald Bagnall, assistant engineer.

For the statement of shipments for Galveston contained in the table herewith, of commercial statistics for the port of Galveston, for the year ending June 30, 1890, I am indebted to Mr. Julius Runge, president of the Galveston Cotton Exchange. For the number, character, and tonnage of vessels entered and cleared for the same period, acknowledgment is due Mr. N. W. Cuney, collector of the port.

The statistics for this and other works in charge of this office were compiled by Mr. Elliott Jones, chief clerk.

It is recommended that the sum of $2,350,000 be appropriated for the fiscal year ending June 30, 1892, of which $850,000 is the amount required for extending the south jetty to the crest of the bar, and $1,500,000 for building the north jetty to the same point.

Original estimated cost of this work, as revised in 1886	$8,478,000.00
Aggregate amount appropriated to July 1, 1890	2,278,000.00
Total amount expended, including outstanding liabilities	2,173,111.66

In addition to this there was expended the sum of $100,000 subscribed by the city of Galveston in 1883.

The work is located in the collection district of Galveston. The nearest lighthouses are at Bolivar Point and Fort Point, at entrance to Galveston Bay.

The amount of revenue collected at the port of Galveston for the fiscal year ending June 30, 1890, was $131,613.17.

The increase in tonnage over last year was 174,008 tons.

ABSTRACT OF APPROPRIATIONS MADE BY CONGRESS FOR IMPROVING HARBOR AT GALVESTON, TEXAS.

By act approved—	
July 11, 1870	*$25,000
March 3, 1871	*20,000
June 10, 1872	*31,000
June 23, 1874	60,000
March 3, 1875	150,000
August 14, 1876	142,000
June 7, 1878	75,000
June 18, 1878	50,000
March 3, 1879	100,000
June 14, 1880	175,000
March 3, 1881	250,000
March 4, 1882	100,000
By act passed August 2, 1882	300,000
By act approved August 5, 1886	300,000
By act of August 11, 1888	500,000
Total	2,278,000

* These appropriations were mostly expended in small dredging operations prior to the adoption of the project of 1874.

Money statement.

July 1, 1889, amount available		$38,763.46
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889, and exclusive of payments made on contracts in force July 1, 1889	$19,022.19	
July 1, 1890, outstanding liabilities	123.25	
		19,145.44
July 1, 1890, balance available		19,618.02
Amount appropriated by act of September 19, 1890		500,000.00
Amount available for fiscal year ending June 30, 1891		519,618.02
Amount (estimated) required for completion of existing project		5,700,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		2,350,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF FIRST LIEUTENANT WILLIAM C. LANGFITT, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., June 30, 1890.

MAJOR: I have the honor to submit the following progress report on the tidal observations of Galveston Bay:

As stated in my last report, three new gauges were put in operation at the places designated, the record from them beginning in July, 1889. The relative elevations of the zeros of the new gauges, referred to the adopted plan of reference, were determined in the usual manner by water comparisons.

It being evident that the presence of a gauge located in the gorge of the harbor would give results of great importance, it was decided, in view of the fact that the records from Round Point and Morgan's Point gauges were so similar that one of them could be dispensed with, to dismantle the Round Point Gauge and establish it in the gorge. This has been done, the Round Point record ceasing in March and the Gorge record commencing in April, 1890. The Round Point tide-gauge house was left standing, with two-staff gauges on different piles, with their zeroes at the same level. A line of precise levels can be run to them at any time and tie in the records already obtained.

On the 3d 4th, 5th, and 6th of April a freshet occurred in the San Jacinto River, during the course of which the current of the river entering Morgan's Canal completely carried away the tide-gauge house at Morgan's Point and the revetment of the canal on the same side as the house. The keeper, Mr. Warren, thoughtfully saved the instrument and all movable property. The gauge was located on the east side of the canal and behind the revetment. It was erected in 1887.

The gauges have been inspected much more frequently this year, resulting in a marked improvement in the records.

A greater part of the time I have been unaided in the reduction and plotting of the records, and have had to compile all numerical data for myself. As a consequence the new matter which I can present in this report is meager, and, in fact, no complete report can be made until further physical data are obtained, notably the relative elevations of the zeros of the gauges; current observations, including relative velocities of ebb and flood currents, with their relative durations and times of slack.

A party is now engaged in running a line of precise levels to connect the various zeros, but the results so far reported have not been received in time to be used.

While I have some data reduced from the records of the new gauges, the results depend upon too few observations to be comparable with those from the older ones; they are consequently reserved for future discussion.

For these reasons the remaining portion of this report is abridged as far as may be, only such results of my reductions being given as will give relatively correct results when compared with my report of last year, together with a short explanation of the cause of the one tide a day during large declinations of the moon.

The following table gives the same facts as given in Table I of the last year's report, revised to include the results of the year 1889, viz, elevation of mean low tide referred to the plane of reference adopted at Galveston, mean fluctuation of the tide at the various gauges for the great and small declination tides, the intermediate tides, and mean of all the tides. The bar record for 1889 is much broken, record having

been obtained in eight months only, no single month complete and some with but very little record at all.

TABLE I.—*Rise and fall of tide.**

Location of gauge.	Plane of M. L. T. above established plane of reference. †	G. D. T.	S. D. T.	I. D. T.	M. T.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Bar	—0.10	2.63	1.27	2.00	1.91
Government Wharf	+0.36	1.57	0.67	1.16	1.05
Rollover	+0.17	1.50	0.94	1.19	1.12
Morgan's Point	+0.56	0.81	0.42	0.67	0.60
Round Point	+0.46	0.85	0.44	0.74	0.65

* Record used begin in May, 1887, and run to include December, 1889. All records more or less broken and some very much so.

† Plane of reference is the plane of M. L. T. at Government Wharf as determined by Mr. Ripley, United States assistant engineer, from observation in 1872 and 1873.

A comparison of this table with that of last year shows:

1. That the plane of M. L. T. at the bar has been largely lowered by the additional observations, while the mean fluctuation has been largely increased. This can be partially accounted for by the fact that the whole number of observations is small and the additional ones introduced happened to contain a relatively large number of tides with very low low-water and large fluctuation.

2. That the plane of M. L. T. at all the gauges has been lowered.

The plane of M. L. T. at the various gauges for 1889 only is as follows:

Bar	−0′.17
Government Wharf	+0′.28
Rollover	+0′.07
Morgan's Point	+0′.53
Round Point	+0′.43

All of which show a lower plane than heretofore.

3. The plane of M. L. T. at Rollover still continues lower than at Government Wharf and its mean fluctation slightly larger.

4. The mean fluctation at all the ganges has been slightly increased.

Tables IV and V of last year's report are combined in the following table, the results being determined from the observations to include 1889.

TABLE II.—*Rise of G. D. T. and S. D. T. divided by rise of M. T.**

Location.	G. D. T. / M. T.	S. D. T. / M. T.
Government Wharf	1.495	0.638
Rollover	1.339	0.750
Morgan's Point	1.350	0.700
Round Point	1.308	0.674

* See remark (*) Table I.

These results give the same indications as those given last year, yet when the absolute differences are so small, a positive conclusion can not be drawn until a longer series of observations confirms the results in their relative values.

Tables II and VI of last year's Report are consolidated in the following table, and extended to include the various classes of tides and the mean tide. These results differ somewhat from the partial determination of the delays in high and low water given last year, but the conclusions are in no wise affected as the relation between the values is still in the same direction. The time of high and low water at the Government Wharf gauge was taken as the origin in the reduction and the results transferred to the bar gauge as an origin by adding to the difference of time found between the Government gauge and the other gauges, the difference of time found between that gauge and the Bar gauge. Owing to the limited amount of record from the Bar gauge, these last differences are not so well determined, but as their absolute amounts are relatively small, the other results are, I think, practically correct.

TABLE III.—*Delay of high and low water.**

Location of gauge.	Distance from Bar Gauge.	Delay high water.				Delay low water.			
		G. D. T.	I. D. T.	S. D. T.	M. T.	G. D. T.	I. D. T.	S. D. T.	M. T.
	Miles.	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*
Government Wharf	6¼	1.28	1.35	1.10	1.226	1.23	1.12	1.01	1.110
Rollover	30	4.63	4.55	4.30	4.474	5.61	5.20	4.79	5.169
Morgan's Point ...	30¾	8.30	7.26	5.26	6.706	6.32	5.89	5.45	5.848
Round Point	35½	8.13	7.02	5.80	6.811	6.62	6.14	5.81	6.153

* See remark (*), Table I.

This table brings out two facts very clearly: (1) That the delay for the large tides is larger than that for the smaller ones; and (2) that the delay in high water is greater than that in low water, the Rollover gauge excepted, this gauge again giving an unexpected result.

Below is given Table VII of last year's Report, revised to include results of 1889. It was obtained by adding to the plane of M. L. T. (Table V) for each kind of tide, its corresponding half fluctuation.

TABLE IV.—*Mid-level of water.**

Location.	G. D. T.	S. D. T.	I. D. T.	M. T.
	Feet.	*Feet.*	*Feet.*	*Feet.*
Bar	0.815	0.915	0.830	0.855
Government Wharf	0.775	0.955	0.880	0.885
Rollover	0.670	0.770	0.725	0.730
Morgan's Point	0.875	0.840	0.875	0.860
Round Point	0.775	0.860	0.770	0.785

* See remark (*), Table I.

This table gives about the same relative results as Table VII of last year's Report, but, as there stated, the quantities are so nearly equal that no positive conclusion can be drawn from them.

In Table VIII of last year's Report I gave the results obtained for the plane of M. L. T. taken out for each kind of tide independently. This table is here repeated, revised to include results of observations of 1889.

TABLE V.—*Plane of M. L. T. for G. D. T., I. D. T., and S. D. T.**

Location of gauge.	G. D. T.	I. D. T.	S. D. T.
	Feet.	*Feet.*	*Feet.*
Bar	−0.50	−0.17	+0.28
Government Wharf	−0.01	+0.30	+0.62
Rollover	−0.08	+0.13	+0.35
Morgan's Point	+0.47	+0.54	+0.63
Round Point	+0.35	+0.40	+0.58

* See remark (*), Table I.

The explanation of these results will be found in the following remarks on the observed tide and its components.

So far as I know no explanation has ever been given by this office for the apparent anomaly of only one tide a day here during parts of a lunation, and two during the remainder. Stated briefly the reason is this: That as the moon leaves her node there is developed a tide having a period approximately of a day, which increases in size as the moon's declination increases (either north or south), and soon passes in magnitude the regular tide which occurs twice a day. This last tide is called the semi-diurnal component, and the former the diurnal component of the observed tide, the latter

Plate 1

Graphical analysis of Tide Curve, Galveston Bar

Jan 28 to Feb. 19. 1890

Note.

Observed curve shown thus ——

Semi diurnal component " — · — ·

Diurnal " " ·····

Vertical lines are 6 hrs. apart

Horizontal " . 1 ft. "

Eng 90

Photo-Lith. by A. HOEN & CO., Balto., Md

Plate II

Graphical analysis of Tide Curve, Gov't. Wharf
Galveston Harbor
Jan 28 to Feb. 19. 1890

Note.
Observed curve shown thus ——
Semi diurnal component " — . — .
Diurnal " " .....
Vertical lines are 6 hrs. apart
Horizontal " " 1 ft.

Photo-Lith. by A. HOEN & CO., Balto., Md

Eng 90

being produced by the combination of the two. Plate I, herewith, presents a graphical analysis of the tide observed at the Bar gauge into its diurnal and semi-diurnal components, and will give a good idea of their relative importance during a lunation.

Assuming that each component follows the law of the sines, either one at any particular time can be represented by an equation of the following form:

$y = \text{A} \cos 2\pi \frac{t}{\text{T}}$ in which

y = ordinate of curve referred to an axis midway between high and low water.
t = time in hours from place of maximum ordinate
T = duration of one tide
A = Coefficient.

Taking two equations of the above form and combining them we get for the equation of the complex curve

$$y = \text{A} \cos\left(2\pi \frac{t}{\text{T}} - \text{E}\right) + \text{A}' \cos 2\pi \frac{t}{\text{T}}, \text{ in which}$$

y = ordinate of complex curve
t, T, and A = same quantities as above.
T, and A′ = quantities for the semi-diurnal curve similar to T and A for the diurnal curve.
E = distance between the place of the maximum ordinate of the diurnal component and the maximum ordinate of preceding semidiurnal component.

For a particular case I deduced the values of the coefficients and of E in the equation and then calculated the resultant curve. This is shown on Plate I, and just below it the corresponding observed curve. The agreement is all that could be expected from such a rough determination.

It is evident that this decomposition explains all or nearly all the circumstances of the rise and fall of the tide; as, for instance, when the moon's declination is large, the sudden rise to high water, the subsequent rapid fall for a short time followed by a more slow decline, stand or small rise, and then rapid fall to low water. These remarks suppose wind effects small.

The value of E in the above equation determines largely the character of the complex curve, as do also the relative magnitudes of the coefficients A and A′. With a correct value of E, and proper changes in value of A and A′ any observed form of curve can be produced. I have not had time nor sufficient data to determine the law of the changes in these coefficients.

These methods of analysis are not new. The graphical method has been used in the office of the U. S. Coast Survey for many years. Again, Professor Bache, formerly superintendent of that service, gives an analytical expression similar in form to the one given above, for the tides at Cat Island, Gulf of Mexico (Report of 1866). His expression is:

$$\text{C} \cos 2t + \text{D} \cos (t - \text{E}) - y = 0,$$

in which t = time in hours from place of maximum ordinate of semi-diurnal curve. C, D, E, and y are similar quantities to A′, A, E, and y in the equation given above.

It may be of interest to state that at Cat Island E is about nine hours, while for Galveston Bar it is about five hours.

On Plate II is given a similar graphical analysis for the tide at the Government Wharf gauge. A comparison of the two will show the changes undergone in passing from the bar to the Government Wharf, a distance of about 6¼ miles.

Before closing this report, I wish to call attention to an error in the last table (VIII) in the published copies of my report of last year. The signs of all the quantities in the table should be *plus*, except that of the top number (0.32) in the column headed G. D. T., which is correctly minus.

Very respectfully, your obedient servant,

WM. C. LANGFITT,
First Lieut., Corps of Engineers.

Maj. CHAS. J. ALLEN,
Corps of Engineers, U. S. A.

REPORT OF MR. H. C. RIPLEY, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., July 1, 1890.

MAJOR: I have the honor to make the following report relating to the improvement of Galveston Harbor, Texas, for the fiscal year ending June 30, 1890:

JETTY CONSTRUCTION.

At the end of the last fiscal year the work under contract with A. M. Shannon & Co. for the construction of the jetty was less than half completed, their contract having been extended at their request to December 31, 1889. At that date the work was still unfinished and the contract was again extended to June 30, 1890. In anticipation that the work would not be finished by the 30th of June the contractors applied for and received a further extension of time to the 30th of August, 1890. The work was therefore continued under the same contract as for the previous year, but by the terms of this contract the expense of inspection and measurement of material, amounting to $4,540.33 has been deducted from payments made to the contractors since the 30th of June, 1889.

CONDITION AND PROGRESS OF THE WORK.

The condition of the work at the end of the year and the progress made were as follows:

The railroad trestle has been extended from station 173+75′ to station 196+28′, a distance of 2,253 feet.

The rock-work has been completed from station 9+60′ to station 70+70′, and from station 71+15′ to station 95+64′ on the shore branch, a distance of 8,559 feet, and from station 150 to station 180 on the Gulf extension, a distance of 3,000 feet, making the total extension of the completed work 11,559 feet. The rock-work is incomplete from station 180 to station 192, a distance of 1,200 feet.

That portion of the work designated as incomplete has progressed as follows:

The riprap work has been built up to full height ready for the placing of blocks to station 181, a length of 100 feet, and the riprap work is incomplete from station 181 to station 192, a length of 1,100 feet.

Blocks have been deposited on the sides of the work in quantity sufficient to nearly complete the covering from station 180 to station 180+50′, a length of 50 feet, and in quantity not nearly sufficient to complete the covering from station 180+50′ to station 191, a length of 1,050 feet.

REPAIRS TO OLD WORK.

At the close of the last fiscal year the repairs to the old work, necessitated by settlement along the axis where clay had been used and by some sliding down of blocks on the sides, were incomplete.

During the year further settlement along the axis and some sliding down on the sides have occurred. The sliding down of blocks, however, has been confided to the north side. The repairs, therefore, have been prosecuted from time to time as were required. There have been expended in these repairs 2,728 cubic yards of riprap and 957 cubic yards of blocks.

AMOUNT OF STONE USED.

The following table (No. 1) shows the number of cars and amount of each kind of stone placed during each month throughout the year.

TABLE NO. 1.—*Showing kind and amount of stone used.*

Month.	Cars.	Riprap.	Cars.	Blocks.	Total cars.
		Cub. yards.		*Cub. yards.*	
July	175	2,807.11	152	1,381.15	327
August	288	4,624.70	211	1,801.93	499
September	187	3,578.06	201	1,791.56	388
October	177	3,116.56	124	1,036.25	301
November	197	3,552.02	171	1,386.32	368
December	240	3,884.73	216	1,585.17	456
January	248	3,980.83	168	1,218.55	416
February	391	6,245.15	297	2,027.95	688
March	514	7,507.31	316	2,044.54	830
April	575	8,071.44	333	2,203.45	908
May	432	6,057.74	248	1,662.04	680
June	356	4,780.81	183	1,120.06	539
Total	3,780	58,206.46	2,620	19,258.97	6,400

It will thus be seen that the total number of cars of stone placed during the year was 6,400. Of these 3,780 cars contained 58,206 cubic yards of riprap and 2,620 cars contained 19,259 cubic yards of blocks, making a total of 77,465 cubic yards of stone placed.

The average amount of stone per car was for riprap $15\frac{2}{5}$ cubic yards and for blocks $7\frac{1}{3}$ cubic yards. The average value of a car of stone was for riprap $32.03 and for blocks $31.61.

METHOD OF CONSTRUCTION.

The method of construction has been similar to that of last year, but a slight modification in the order of placing the stone has resulted in a smaller cross-section and consequent reduction in cost.

Instead of depositing the whole amount of riprap and bringing it to full height before the blocks were deposited, as was done last year, the riprap was only brought up to the water-surface and then blocks were deposited on the sides, bringing them to a height somewhat above that of the riprap.

Additional riprap was then deposited and brought to full height, the presence of the blocks on the side preventing any of the riprap from rolling down on the sides, and hence any increase in the width of the core was impossible.

Additional blocks were then deposited and placed with the derrick as before.

This order of placing the stone extends from station 165 onward, and has resulted in a reduction in cost of not less than $10 per lineal foot.

COST OF THE WORK.

The following table (No. 2) shows the quantities of stone used and the cost of the same in the work, and other items of expense, not including office and inspection expenses. Previous expenditures are also included in the table, so that the grand total gives the total cost of the work to date under the project of 1886.

TABLE No. 2.—*Showing quantities of stone used and cost of the same in the work, and other items of expense, not including office and inspection expenses.*

Items.	0 to 79+64 feet (7,964 feet).				79+64 feet to 84+64 feet (500 feet).			
	Cubic yards.	Cost.	Cubic yards per foot.	Cost per foot.	Cubic yards.	Cost.	Cubic yards per foot.	Cost per foot.
Riprap	5,179.30	$10,772.94	.65	$1.35	332.53	$691.66	.67	$1.38
Blocks	2,622.79	11,278.00	.33	1.41	797.28	3,428.30	1.59	6.86
Railway						34.90		.07
Extras		47.92		.01		1.99		
Total for year	7,802.09	22,098.86	.98	2.77	1,129.81	4,156.85	2.26	8.31
Previous expenditures	32,278.15	113,582.22	4.05	14.26	4,869.00	12,029.99	9.74	24.06
Grand total	40,080.24	135,681.08	5.03	17.04	5,998.81	16,186.84	12.00	32.37

Items.	84+64 feet to 95+64 feet (1,100 feet).				95+64 feet to 107+64 feet (1,200 feet).			
Riprap	537.65	1,118.31	.49	1.02	710.95	1,478.78	.59	1.23
Blocks	1,611.86	6,931.00	1.47	6.30	150.53	647.28	.13	.54
Railway		45.77		.04		51.64		.04
Extras		49.84		.05		4.78		
Total for year	2,149.51	8,144.92	1.95	7.40	861.48	2,182.48	.72	1.82
Previous expenditures	7,445.00	20,776.13	6.77	18.89	11,855.00	37,314.64	9.88	31.10
Grand total	9,594.51	28,921.05	8.72	26.30	12,716.48	39,497.12	10.60	32.92

TABLE NO. 2.—*Showing quantities of stone used and the cost of the same, etc.*—C

Items.	107+64 feet to 138+64 feet (3,100 feet).				138+64 feet to 144+12 feet (548 feet).			
	Cubic yards.	Cost.	Cubic yards per foot.	Cost per foot.	Cubic yards.	Cost.	Cubic yards per foot.	Cost per foot.
Riprap	1,894.31	$3,940.16	.61	$1.27	122.78	$255.38	.22	$0.47
Blocks	730.78	3,142.35	.24	1.01	75.84	326.11	.14	.60
Railway	.....	298.32	.....	.10	.....	35.95	.....	.06
Extras	.....	20.09	.....	.01	.....	3.69	.....	.01
Total for year	2,625.09	7,400.92	.85	2.39	198.62	621.13	.36	1.13
Previous expenditures	69,555.00	208,554.70	22.44	67.28	12,369.00	38,446.75	22.57	70.16
Grand total	72,180.09	215,955.62	23.28	69.66	12,567.62	39,067.88	22.93	71.29

Items.	144+12 feet to 150 (588 feet).				150 to 160 (1,000 feet).			
Riprap	413.87	860.85	.70	1.46	12,416.29	25,825.88	12.42	25.83
Blocks	13.81	59.38	.02	10	4,598.02	19,771.49	4.60	19.77
Railway	.....	.....	.....	.....	.....	.....	.....	.....
Extras	.....	52.39	.....	09	.....	3.98	.....	.....
Total for year	427.68	972.62	73	1.66	17,014.31	45,601.35	17.01	45.60
Previous expenditures	12,313.00	33,306.03	20.94	56.64	2,609.00	8,934.40	2.61	8.93
Grand total	12,740.68	34,278.65	21.67	58.30	19,623.31	54,535.75	19.62	54.54

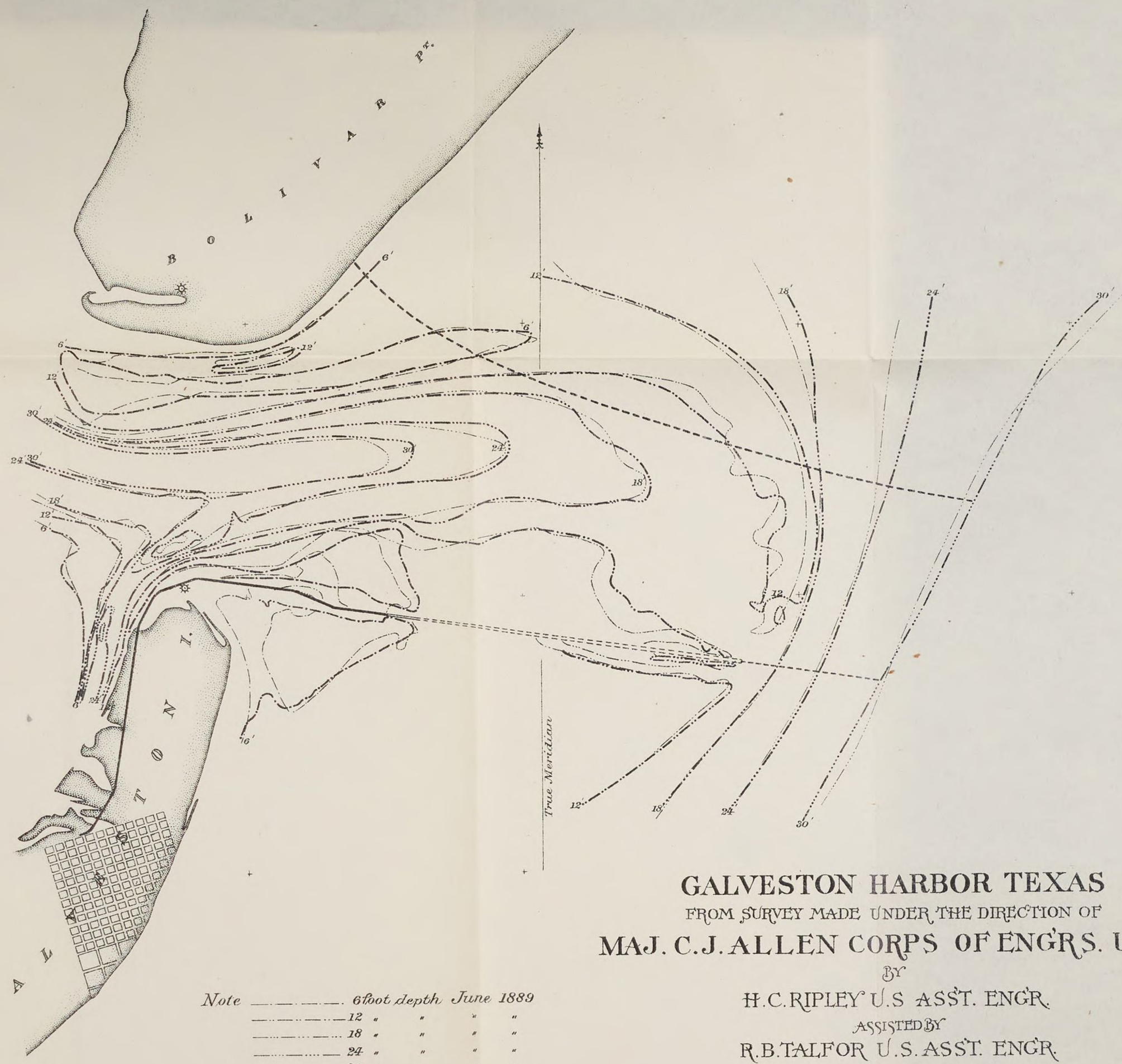
Items.	160 to 170 (1,000 feet.)				170 to 180 (1,000 feet.)			
Riprap	15,415.57	32,064.39	15.42	32.06	9,720.28	20,218.18	9.72	20.22
Blocks	4,624.20	18,336.06	4.26	18.34	3,442.39	14,802.28	3.44	14.80
Railway	.....	.....	.....	.....	.....	2,031.25	.....	2.03
Extras	.....	21.21	.....	02	.....	6.98	.....	.01
Total for year	19,679.77	50,421.66	19.68	50.42	13,162.67	37,058.69	13.16	37.06
Previous expenditures	.....	3,282.23	.....	3.28	.....	1,230.84	.....	1.23
Grand total	19,679.77	53,703.89	19.68	53.70	13,162.67	38,289.53	13.16	38.29

Items.	180 to 190 feet (1,000 feet) incomplete.				190 to 196+28 feet (628 feet) incomplete.			
Riprap	9,569.20	19,903.94	9.57	19.90	1,893.41	3,938.29	3.01	6.27
Blocks	885.72	3,808.60	.89	3.81	65.72	282.60	.10	.45
Railway	.....	3,265.56	.....	3.27	.....	2,168.19	.....	3.45
Extras	.....	30.98	.....	.03	.....	28.48	.....	.05
Total for year	10,454.92	27,009.08	10.45	27.01	1,959.13	6,417.56	3.12	10.22
Previous expenditures	.....	.....	.....	.....	.....	.....	.....	.....
Grand total	10,454.92	27,009.08	10.45	27.01	1,959.13	6,417.56	3.12	10.22

It will thus be seen that the average cost per foot of jetty has been as follows:

From station 0 to station 79+64′, $17.04; from station 79+64′ to station 84+64′, $32.37; from station 84+64′ to station 95+64′, $26.30; from station 95+64′ to station 107+64′, $32.92; from station 107+64′ to station 138+64′, $69.66; from station 138+64′ to station 144+12′, $71.29; from station 144+12′ to station 150, $58.30; from station 150 to station 160, $54.54; from station 160 to station 170, $53.70; from station 170 to station 180, $38.29; from station 180 to station 190 (unfinished), $27.01; and from station 190 to station 196+28′ (unfinished), $10.22.

The cost of the repairs to the old work for the year from station 95+64′ to station 144+12′ has been at the rate $2 per lineal foot, which is about 3⅛ per cent. of the total cost to date.



GALVESTON HARBOR TEXAS

FROM SURVEY MADE UNDER THE DIRECTION OF

MAJ. C.J. ALLEN CORPS OF ENGRS. U.S.A.

BY

H.C. RIPLEY U.S ASST. ENGR.

ASSISTED BY

R.B. TALFOR U.S. ASST. ENGR.

IN APRIL & MAY

1890

SCALE OF FEET

1000 0 1000 2000 3000 4000 5000

To accompany annual report June 30th 1890

Note ——·——·——· 6 foot depth June 1889
——·——··——·— 12 " " " "
——·——··——··— 18 " " " "
——·——···——···— 24 " " " "
——·——···——···— 30 " " " "
—·—·—·—· 6 " " " 1890
——·——··——·— 12 " " " "
——·——··——··— 18 " " " "
——·——···——···— 24 " " " "
——·——···——···— 30 " " " "
——— Shore Line " 1889

Photo-Lith. by A. HOEN & CO., Balto., Md.



The cost of the repairs to the track over the same length for the year has been at the rate of 8 cents per foot.

SOURCES OF SUPPLY.

The stone used during the year has been brought by rail from three places, as follows:

Riverside, on the line of the International and Great Northern Railway, 130 miles from Galveston; Quarry Station and Heber Stone Quarry on the line of the Gulf, Colorado and Santa Fé Railway, the former 143 miles and the latter 153 miles from Galveston. The supply, however, has come mainly from the Heber Stone Quarry, as only about 4 per cent. has come from Riverside and 6 per cent. from Quarry Station, of the whole amount received.

SURVEYS.

At the close of the last fiscal year a portion of the field notes of the annual survey had not been plotted and hence the changes in the hydrography of the inner harbor and in the shore-lines was not given in my last annual report. These omissions were supplied in my report of November 16, 1889.

During December and January last a survey was made embracing an area of about 9 square miles of hydrography, extending from the 30-foot depth in Bolivar Channel to the same depth in the Gulf, and for a width sufficient to cover that portion of the outer bar probably liable to change; also the shore-line extending from the foot of Tremont street along the Gulf shore to the jetty, a distance of about 4 miles. The results of this survey were given in my report of February 8, 1890.

During April, May, and June a complete survey of the harbor and entrance was made. The hydrography embraces an area of about 30 square miles and includes the outer bar to a depth of 30 feet in the Gulf and the inner harbor to the limit of the 12-foot depth. The soundings were taken between April 17 and May 31.

The topography embraces the mean high and mean low-water shore-lines of the east end of Galveston Island, the north shore of Pelican Island and Spit, and the west end of Bolivar Peninsula, an aggregate length of shore of about 21 miles.

The shore-line locations were executed in June. For want of time only a portion of the notes have been plotted. Embraced in these are the shore-line locations and that portion of the hydrographic work west of the 30-foot depth in Bolivar Channel and north of Pelican Island.

Comparing the results obtained, however, with the survey of one year ago, we find that the Galveston Channel has suffered only slight changes, and these are favorable to an increased width and depth. At its shoalest point the depth has apparently increased from 21 to 22 feet, although the shoal area is not covered with soundings as well as could be desired, and the width between the 20-foot contours at the narrowest part of the channel has increased from 300 to 360 feet. The area embraced in the 30-foot contour near its junction with Bolivar Channel has considerably enlarged, increasing its length from 1,340 feet to 1,940 feet and its width from 200 feet to 500 feet.

In Bolivar Channel the changes have been more extensive. West of its junction with Galveston Channel the width of the 30-foot area has somewhat diminished. The contour on the north side of the channel has moved south about 200 feet, and on the south side of the channel this contour has fluctuated somewhat, but on the whole has maintained about the same position as last year. The width, therefore, between these contours has diminished about 200 feet. There has also been some southerly movement of the 18-foot and 24-foot contours, but less in amount. East of its junction with Galveston Channel there has been some enlargement of its deep-water areas. The 30-foot depth has advanced gulfward about 1,000 feet, the 24-foot depth about 200 feet, the 20-foot depth about 350 feet, and the 18-foot depth about 200 feet.

The 24-foot area has also been enlarged mainly on the north side near its outer end. Upon the crest of the outer bar there has been a pretty general shoaling of from one-fourth to one-half of a foot. The depth in the jetty channel, however, still remains at 13¼ feet, but the width of the channel between the 13-foot contours has considerably diminished and the distance from the 14-foot depth inside to the 14-foot depth outside has increased from 2,000 feet to 2,600 feet. The bar has also advanced very perceptibly gulfward.

On the Gulf side of the bar from the jetty northward the average and maximum advance is as follows:

For the 12-foot contour the average is about 300 feet and the maximum 470 feet; for the 18-foot contour the average is about 200 feet and the maximum 540 feet; for the 20-foot contour the average is about 400 feet and the maximum 740 feet; for the 24-foot contour the average is about 600 feet and the maximum 1,100 feet, and for the 30-foot contour the average is about 200 feet and the maximum 340 feet.

The long shoal north of Bolivar Channel and separating it from the swash or shore channel has increased its height somewhat and has been extended eastward, the 8-foot contours having advanced about 1,000 feet, while its western end has been cut away, the 12-foot and 8-foot contours having receded about 650 feet. For a length of about 6,000 feet immediately south of Bolivar Point this shoal has moved bodily towards Bolivar Channel, as has also the swash channel for nearly the same distance. The amount of this movement is about 200 feet. The depth in the swash channel has suffered no further increase since last year.

The shoal immediately north of the jetty has continued its gulfward advance. The amount of this advance is for the 6-foot contour about 600 feet, for the 8-foot contour about 350 feet, and for the 12-foot contour about 800 feet.

The shallow trench along the north edge of the old mattress jetty near its outer end, which had developed last year, has become entirely obliterated, and the indications are that the probable effect of the further building up of the south jetty will be the obliteration of the jetty channel itself. The shoal immediately south of the jetty has apparently ceased its westward movement and has commenced extending itself eastward. An island has been formed at its western end which at average tides is about 1,000 feet long and at its highest point about 4 feet above the water-surface. The shore of Fort Point and this island are approaching each other and will probably join in the near future. The amount of the eastward advance of this shoal is for the 3-foot contour about 1,500 feet and for the 8-foot contour about 640 feet. The little bay between Fort Point light-house and this new island has shoaled from 1 to 2 feet. The deep trench on the south side of and along the outer portion of the old mattress jetty has diminished somewhat in extent and depth, although the reduction in these respects is much less than for the previous year. It will be noted that the deepest water is no longer close to the base of the work, but is at a distance of from 140 to 240 feet therefrom.

These changes indicate a further increase in the outward resultant of force and may be reasonably attributed to the further extension of the jetty work. The erosion at the west end of the shoal north of Bolivar Channel is an indication of a relative weakening of the flood component of force at that point. This point being so remote from the artificial works and being to the rear of them, and the result being exactly the opposite of what should have been expected if we consider only the direct action of the jetty itself, an explanation must be sought in a change in the character of the tidal currents as a result of these artificial works. An investigation in water slopes and other tidal phenomena made in February last and which was submitted to you on the 14th of that month in a paper entitled "Tidal Phenomena of Galveston Harbor" brought out some facts which have so direct a bearing upon this subject and furnish so reasonable an explanation for this change that I beg to include that paper as a part of my annual report. That investigation brought out the fact that any obstruction to the tidal flow to and from the bay would increase the ebb slopes and reduce the flood slopes and the cutting off of the west end of the north shoal would seem to indicate that the work done upon the jetty has already had an appreciable effect upon the character of the tidal currents in the harbor in the direction indicated by theory. The gulfward advance of the bar is not an unexpected result of the extension of the jetty, and I think we may expect a continuation of this advance until the equilibrium has been restored or the supply of sand exhausted.

It has been seen that the greatest shoaling in the deep trench along the south side of the old mattress jetty near its outer end has been near the base of the work. This indicates that the sand has accumulated on the north side of the jetty and some has passed over the crest and settled next to the base. This is another indication of the loss of force in the littoral current at that point, and also shows from which direction the sand is moving that has caused the shoaling in the trench itself. To be sure this sand may have been brought out of the harbor by the ebb currents, but the fact to be emphasized is that this material did not come from the west.

PROFILE OF SOUTH JETTY.

The profile of the old mattress portion of the south jetty compared with that of one year ago shows no indication of any further subsidence of that work. Indeed, the result of the more numerous soundings taken this year over last year gives a somewhat greater average height to that work than the average of last year. Commencing at the outer end, the average depth on the axis for the first 5,000 feet is 8.71 feet, for the second 5,000 feet is 7.88 feet, and for the next 2,400 feet it is 8.71 feet. This shows a subsidence of the outer 5,000 feet of but .45 of a foot in the last two years. No comparison for the balance of the distance can be made from the fact that for the last two years most of this portion has been covered with sand. It is probable, therefore, that no subsidence has occurred.

EXAMINATION OF NEW WORK.

Bimonthly soundings of the bottom adjacent to the new work have been taken from Station 80 onward, throughout the year, at intervals of 200 feet, in order to detect any changes which might occur that would endanger the foundation of the work. These soundings have been plotted and have accompanied my monthly reports, showing a comparison with those previously taken. The annual cross-sections and profile of the work for comparison with those taken last June have not been taken, however.

It was found that an increase of the engineering force would be necessary to complete them in time for the annual report, and also in consideration of the fact that the contract will be completed two months hence. It was therefore decided to defer the sections until a later date. When these are taken the results will be made the subject of a supplemental report.

Very respectfully, your obedient servant,

H. C. RIPLEY,
Assistant Engineer.

Maj. CHAS. J. ALLEN,
Corps of Engineers, U. S. A.

REPORT OF MR. GERALD BAGNALL, ASSISTANT ENGINEER.

GALVESTON, TEX., *July* 4, 1890.

SIR: I have the honor to make the following report on the precise leveling operations which are about to be suspended. It is impossible, however, to give more than a short outline of what has been done, as the field notes have not yet been worked up.

One leveling party was organized on March 20, and commenced running a line up Bolivar Peninsula, starting from the light-house. The party consisted of Mr. A. L. Johnson, observer in charge; Mr. T. P. Griffith, recorder; and Messrs. G. W. Allen and Houston Jones, rodmen, and three attendants and axemen. It was proposed to run a line around Galveston Bay, commencing at Bolivar Point, to be afterwards connected with the different tide gauges in the bay. This plan, however, as the work progressed and the difficulty of leveling over marsh land and of going around the flooded country adjacent to the Trinity, San Jacinto, and other streams became more apparent, was abandoned in favor of one which contemplated the starting of two separate lines from Galveston; one across the gorge, to connect with the Gorge, Bar, Hannah's Reef, and Rollover gauges; the other to cross West Bay and connect with the two Red Fish and Morgan's Point gauges. This latter plan, however, could not be adopted until the practicability of taking long shots across water on platforms had been tested. As no information on this subject could be found in reports of leveling done heretofore, it was decided to connect the B. M. at Elm Grove with the Hannah's Reef gauge, as an experiment, before proceeding further. Platforms were accordingly constructed and reciprocal levels taken across two spans one-quarter mile long, two spans one-half mile long, with check lines across one span one-half mile, and one of 1 mile. Although but one series was taken in each of these check lines the greatest discrepancy found was only 4 millimeters, from which it may be safely assumed that the results obtained by the levels across the four spans is fully up to the standard of accuracy required on shore work.

The platforms consisted of three piles, well braced, for the instrument to stand on, surrounded by sheet-piling to protect them from the force of the waves, and were 6 feet high above the water. The practicability of taking shots of at least a mile caused the adoption of the plan which embraced crossing the gorge, and work was commenced there immediately on the completion of the Elm Grove work. Platforms were erected off Pelican Spit, on Bird Island Shoal, and near the gorge gauge. These, as at Elm Grove, consisted of a triangle of sheet-piling with three piles in the center, but they had to be of much stronger construction, and with the exception of one on Bird Island Shoal had a stone apron around them to prevent scour. The latter was carried away, the current having scoured out around it before stone could be placed.

It was decided not to rebuild the platform on Bird Island Shoal, but to run from Quarantine to the gauge platform by Pelican, and also from Fort Point light-house, and thence to Bolivar Peninsula, also by two different routes, thus getting a complete check across the gorge. From Quarantine to gorge gauge platform, going by Pelican, embraces one span of 4,500 feet and one of 6,200 feet, going by Fort Point light-house one span of 5,900 feet, these lines checked to within 1.8 millimeters. The two lines from gorge gauge platform to Bolivar also checked well.

One platform has been constructed on the bar at a distance of one mile from shore. It resembles the others in design, but is stronger and has a wave-breaker of piling 20 feet, and from the sheet-piling on the exposed sides.

On the completion of this platform it was decided to suspend work on account of want of sufficient funds to complete it.

The unprecedented weather of April, May, and part of June retarded the work very seriously. During that period only about 10 per cent. of the time was suitable for leveling on platforms, and to this cause must be attributed the failure to complete the work with the money allotted.

During the progress of the work current measurements were taken when possible, especially with regard to the flow of water through Bolivar Beach Channel. The observations taken show a strong current both at ebb and flood tide through that channel.

A continuous line of levels has now been finished to Hannah's Reef gauge, connecting it with the Gorge gauge and the Hendley Building, and one of the three platforms required to connect the bar gauge completed.

It is to be regretted that the results obtained can not be given in this report. The work, which under the most favorable circumstances would require the greatest care, was rendered very much more difficult by the physical condition of the locality and by the unfavorable weather.

Before concluding I wish to acknowledge the service of Mr. A. L. Johnson, assistant engineer, to whose assistance the success of the work is largely due. Thanks are also due the other members of the party for their faithful services.

Very respectfully, your obedient servant,

GERALD BAGNALL,
Assistant Engineer.

Maj. CHAS. J. ALLEN,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS OF GALVESTON HARBOR, TEXAS, FOR FISCAL YEAR ENDING JUNE 30, 1890.

[Compiled from statements made by Julius Runge, esq., president of the cotton exchange, and N. W. Cuney esq., collector of the port of Galveston, Texas.]

Steam-vessels entered		302
Sailing vessels entered		145
Total		447
Steam-vessels cleared		304
Sailing vessels cleared		118
Total		422
Total tonnage of vessels entered	tons..	501,695
Total tonnage of vessels cleared	do...	492,667
Total tonnage		964,372

Amount and value of freight shipped.

Articles.	Tons.	Approximate value.	Approximate freight charges.
Cotton (853,000 bales)	223,486	$46,900,000	$3,533,625
Wool (68,800 bags)	6,883	2,712,000	82,594
Cotton-seed cake (921,000 bags)	69,095	1,313,000	414,571
Cott n-seed oil (50,649 barrels)	10,045	633,115	50,649
Total	309,509	51,558,115	4,070,439

In addition to the above there was a large quantity of general merchandise shipped, the amount of which could not be determined.

Increase of tonnage over last year, 174,008 tons.

Comparative statement of commercial statistics of the port of Galveston for the fiscal years ending June 30, 1887, 1888, 1889, *and* 1890.

	Entered.		Cleared.		Tonnage.		Total tonnage.	Revenue collected.
	Steam.	Sail.	Steam.	Sail.	Entered.	Cleared.		
1887	250	296	256	238	446,711	444,801	891,512	$172,894
1888	259	231	249	193	447,144	432,588	879,732	234,908
1889	250	131	244	124	416,468	403,896	820,364	153,040
1890	302	145	304	118	501,695	492,677	994,372	131,613

DEEP HARBOR ON THE NORTHWEST COAST OF THE GULF OF MEXICO.

REPORT OF BOARD OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Philadelphia, Pa., December 11, 1889.

GENERAL: The Board of Engineers constituted by Special Orders, No. 29, Headquarters Corps of Engineers, March 16, 1889, has the honor to submit the following report:

The duties of the Board are fully set forth in the following extract from the act of Congress (Public No. 154, approved March 2, 1889) under which the Board was appointed:

Surveys for deep-water harbor, Gulf of Mexico.—The Secretary of War is hereby authorized and directed to appoint a board of three engineer officers of the United States Army, whose duty it shall be to make a careful and critical examination of the northwest coast of the Gulf of Mexico, west of ninety-three degrees and thirty minutes west longitude, and report as to the most eligible point or points for a deep harbor, to be of ample depth, width, and capacity to accommodate the largest ocean-going vessels and the commercial and naval necessities of the country, which can be secured and maintained in the shortest time and at the least cost: *Provided*, That this action shall not be construed to imply a cessation of work on other points on the Gulf coast, the improvement of which is deemed necessary for commercial or naval purposes. And the Board of Engineers shall report the result of its investigations to the Secretary of War as soon as practicable.

The Board met at the United States engineer office in New Orleans at 10 a. m. May 6, 1889, and examined the records of that office pertaining to the subject, including charts and surveys relating to Sabine Pass. They also heard the views of a committee of gentlemen interested in this pass, and at their request the Board changed its plan so as to visit the pass by way of Orange, returning by way of Beaumont.

The same evening the Board left New Orleans, accompanied by the committee and by Capt. W. L. Fisk, the engineer officer in charge of the works for the improvement of Sabine Pass, arriving at Orange at 5.30 a. m., and by 8 o'clock were descending the Sabine River on a steamer placed at their disposal by the committee. The Board crossed Sabine Lake, and after examining the method of mattress construction, inspected the pass on a tug and had soundings taken across the bar. After returning to the village of Sabine Pass they proceeded to Beaumont that evening by rail, and the next morning, the 8th, left for Galveston. At

Galveston the Board examined the charts and surveys of the various harbors on the Texas coast, besides visiting the inner and outer harbors and the works of improvement at Galveston. On Friday, May 10, a public hearing was given to the citizens of Galveston, and on the following day, at 6 a. m., the Board took the train for Rockport, arriving at 9.40 p. m. Major Ernst, the engineer officer in charge of the Texas district, accompanied the board from Galveston, and at Kenedy they were joined by a delegation from San Antonio and Dallas, specially interested in the improvement of Aransas Pass. Next day the party proceeded down Aransas Bay to the pass and examined the works in progress there, returning to Rockport, which place they left at 6 o'clock next morning on the cars for Corpus Christi.

At 10 a. m., May 13, the Board gave a public hearing to the citizens of Corpus Christi, and at 2 p. m. started down Corpus Christi Bay on a tug, and crossing the bar at Aransas Pass in a sail-boat reached the United States revenue-cutter *John A. Dix*, which had been kindly placed at the disposal of the Board by the Secretary of the Treasury. At 9 a. m., May 14, the cutter was off the bar at Brazos Santiago, the most southerly port of the coast of Texas, and in a small boat the Board examined the bar and harbor as far as Point Isabel.

The next day, May 15, at 11.30 a. m., the Board arrived at Pass Cavallo, and crossing the bar in the revenue-cutter examined the harbor as far as inside of Decros Point.

May 16, at 7.30 a. m., the Board left the revenue-cutter in a small boat and crossed the bar at the mouth of the Brazos River and inspected the works of improvement in progress at that place. The same afternoon the Board arrived at Galveston, having completed the examination of the coast of Texas.

At the request of the Board of Trade of San Antonio that a visit should be made to that city, the Board left Galveston by rail at 6 a. m., May 17, reaching San Antonio at 7.30 p. m. After seeing and hearing what the business men of San Antonio had to present for consideration, at 3.30 p. m., the Board left for Austin, where an interview was had with the governor of the State. The next morning the Board proceeded to Galveston.

The required personal examination of all the harbors on the Gulf coast from Louisiana to Mexico had now been completed, after giving in each instance previous notice of dates so as to permit all who desired it an opportunity of presenting their views, verbally or in writing.

The facts and opinions which had been presented for the information and consideration of the Board were very voluminous, and as time was necessary to sort and analyze them as well as to study charts and reports of previous surveys, the Board deemed it best to adjourn on the 20th of May to re-assemble at the call of the senior officer.

The board reconvened at the United States engineer office, Philadelphia, September 27, 1889, and after a session of two days, again adjourned to reconvene at the call of the senior officer.

The final meeting was held in Philadelphia in a session of several days, commencing December 5, 1889, at which time the conclusions given in this report were reached.

Preparatory to the description of the harbors in detail, and to the examination of the special conditions which afford means for determining the comparative eligibility of the various points for a deep-water harbor on the Gulf coast, the Board will briefly outline the character of the formation of the Gulf coast, along which the harbors are found, for the better understanding of the conditions to which references will be made in the discussions to follow.

THE PASSES AND HARBORS ON THE NORTHWEST COAST OF THE GULF OF MEXICO.

The northwest coast of the Gulf of Mexico, comprising the entire Gulf coast of the State of Texas, has a length of about 375 statute miles. For about four-fifths of this distance there is outside of the mainland shallow lagoons, separated from the Gulf by long, narrow sandy islands or peninsulas. One of these islands, the Padre Island, is 100 miles long. While these lagoons cover extended areas, yet the rise and fall of ordinary tides being only about 1 foot, they alone could not maintain channels of any size between the Gulf and the lagoons. Long-continued gales are the effective factor in producing and maintaining a connection between the lagoons and the Gulf. The Board of Engineers in a report of November 11, 1887, upon the surveys of the entrances of several Texas harbors so well state the facts that we quote from their report as follows:

> These harbors all have characteristic features in common. A sandy cordon, thrown up by waves and littoral currents due to winds, extends along the whole shore, often forming a series of lagoons between itself and the mainland. The rivers of Texas are small, and at seasons of low water have too insignificant discharges to scour their outlets into the Gulf. The lagoons, shallow and often mutually connected, cover inside the passes extensive areas; but unfortunately the tidal oscillation which supplies the only constant power available for deepening the passes through the cordon is only about 1 foot in height. Hence, the volume of tidal flow to and from the lagoons is ordinarily small and the currents consequently weak, notwithstanding the immense areas of many of these basins. When, however, long continued southeasterly gales have raised the water-level behind the cordon several feet a sudden norther will force out an immense volume, and in so short a time as to generate a current destructive to ordinary contraction works. (Report of Chief of Engineers, 1888, page 1299.)

The rivers of Texas are of two classes, those that debouch directly into the Gulf, and those that debouch into a lagoon connecting with the Gulf by an inlet. The Brazos is the only example of the former class that has ever been thought worthy of examination with the view to improvement for commercial purposes.

The following is a list of all the passes with interior lagoons along the coast, covering a length of 375 miles, approximately, arranged in geographical sequence, inclusive of the mouth of the Brazos River, which has no enlarged estuary at the entrance:

Sabine Pass; Galveston Harbor, entrance to; San Luis Pass; Brazos River, mouth of; Pass Cavallo, inlet to Matagorda Bay; Cedar Bayou; Aransas Pass; Corpus Christi Pass; Brazos Santiago.

The Boca Chica, which was formerly the extreme southern pass, was closed in 1868, and therefore has no existence now except on the maps.

A project has been submitted to the Board for the construction of an outer harbor off Padre Island, to be known as Willet's Harbor, which will be considered in connection with the above-mentioned points. The United States with intermittent and inadequate appropriations attempted improvements at the mouth of the Brazos River, Pass Cavallo, and Brazos Santiago, but the constructive works have been destroyed and operations for the time being are suspended.

The United States is now limiting its work on harbors for this coast to Sabine Pass, Galveston, and Aransas Pass, where the works heretofore constructed have sustained great loss and injury owing to lack of adequate appropriations for continuous and vigorous prosecution.

The Board now presents a concise description of each entrance separately, referring only to the salient features which affect the questions under consideration.

OUTER HARBOR, OFF PADRE ISLAND.

The attention of the Board has been called to a proposed artificial harbor to be built outside Padre Island, where the deep water of the Gulf approaches very close to the coast. The proposition is to extend a pier into the Gulf until deep water is reached, say a depth of 30 feet, and then to construct two other piers at right angles to the first, these three piers partially inclosing a protected area, in which docks are provided by building small piers from the main ones. The piers are provided with railroad tracks, which connect the harbor with the mainland. In connection with the piers it is proposed to apply an invention for floating breakwaters.

This project is almost equally applicable at a number of points on the coast so far as engineering difficulties and cost are concerned. The eligibility of the location for such a work would depend to a large extent upon questions relating to railroads and real estate, as well as the distance from shore to deep water.

The Board is of opinion that the object sought by the act under which it was constituted can not be best attained by the construction of an outer harbor, and therefore it is not called upon for a discussion of the merits of the special plan submitted to it for Willet's Harbor off Padre Island.

THE MOUTH OF THE BRAZOS RIVER.

The Brazos River is about 800 miles long, is navigable at low water for a distance of about 50 miles above its mouth, and flows directly into the Gulf, instead of into a bay as is usual with Texas rivers. Its mouth is about 15 miles southwest of San Luis Pass. The bar at its mouth has been very unstable, scouring at times to a depth of 8.5 feet and again shoaling to 3 feet or less. The cross-section of the narrowest part of the river inside the bar also fluctuates greatly, varying, at the times of the different surveys during the last twenty-five years, between a maximum of 6,708 square feet and a minimum of 2,500 square feet. These great variations are doubtless mainly due to the freshets which are very violent, the difference between extreme high and low water being occasionally as great as 42 feet at Bolivar Landing, about 50 miles from the mouth, and 38 feet at Waco, 430 miles above the mouth.

The United States attempted slight improvements of the bar with inadequate means, but as the object sought by Congress was a naval station or harbor of refuge, for neither of which was the locality adapted, its improvement by the United States was abandoned and a private corporation was authorized by act of Congress, August, 1888, to construct and maintain works of improvement at this point at its own expense and for its own benefit. This corporation is now engaged in constructing two parallel piers about 550 feet apart, in extension of the river banks. When the Board inspected the work the south pier was being pushed forward with great energy and skill. It was understood that funds were available to complete the entire work in one season, thus avoiding the exposure of incomplete work to destruction. At the narrowest part of the river just inside the Gulf shore-line, nature has been able to maintain a channel which has varied greatly in its dimensions, but when surveyed has always had a cross-section very much less than the Board considers the minimum for the entrance to a deep harbor.

CEDAR BAYOU.

This is a narrow shallow connection between Mesquite Bay and the Gulf, about 20 miles northeast of Aransas Pass. It is about 4 miles long, has only 3 feet of water at the entrance, and 4½ feet in the bayou. It has never been examined with a view to improvement, and is not worthy of being considered in connection with a site for a deep-water harbor.

CORPUS CHRISTI PASS.

This pass is at the southwestern extremity of Corpus Christi Bay and nearly 20 miles southwest of Aransas Pass. It is very narrow, at places not over 700 feet between shore lines, with only 5 feet of water on the bar at its mouth and less than 3 feet at its head in Corpus Christi Bay. It is more than 6 miles in a straight line from the head to the mouth of the pass. This pass is entirely too small to be considered in connection with a deep-water harbor, and it is so unimportant as a navigable pass that the engineer officer in charge of the district at one time recommended its closure by a low dam in connection with improvements at another point.

BRAZOS SANTIAGO ENTRANCE.

This is the southern entrance to the Laguna Madre, which is 100 miles long, extending to Corpus Christi Pass. The channel had at the time of the last survey, 1887, 7½ feet of water on the bar, but it shifts its direction in different parts of the year so that the pilots sound the bar before the arrival of each steamer. Inside the bar the bay is very shallow and furnishes but slight shelter. At the narrowest part of the pass the width is only 500 feet, the maximum depth 31 feet, and the area of the cross-section about 10,000 square feet. It has been estimated by the engineer officer in charge that it will cost $1,130,000 to construct jetties out to the 12-foot curve. The last Congress made no appropriation for this work. The cross-section maintained by nature at the gorge is entirely too small to give reasonable promise of maintaining a suitable artificial channel for the largest modern vessels. In addition to this, Brazos Santiago being at the southwestern extremity of our territory, is not well located geographically for the site of the deep-water harbor for the northwest coast of the Gulf of Mexico.

SAN LUIS PASS.

This pass is at the southern end of Galveston Island, which is about 28 miles long. The pass has a cross-section at its narrowest part of probably about 20,000 square feet with a width of 1,600 feet. The channel across the bar has a depth of 8 feet according to the latest Coast Survey chart.

No appropriation has ever been made for the survey or improvement of this pass, and consequently there is not as much data at hand as in the other cases. A scheme for its improvement has been submitted to the Board, but as the duties of the Board are confined to determining the most eligible point, or points, on the coast of Texas for a deep-water harbor, they have not felt called upon to consider any other question relating to the improvement of the harbors on the Gulf coast. The Board has not heard of any one that deems this the best point for a deep-water harbor, nor does the Board deem it worthy of consideration in comparison with several other points.

PASS CAVALLO, INLET TO MATAGORDA BAY.

This pass may be said to extend north and south, with Matogorda Island on the west and Pelican Island and Shoal on the east. A great part of the water entering and leaving Matagorda Bay passes over Pelican Shoal, and between this shoal and Matagorda Peninsula which lies a mile and a half north of Pelican Island. The pass proper, between Matagorda Island and Pelican Island is about 3,300 feet wide, or 2,000 feet between the 6-foot curves, and nearly 1,200 feet between the 18-foot curves, with a maximum depth of 32 feet and a cross-section of about 40,000 square feet. Farther south the 6-foot curve of Pelican Shoal presses closer to Matagorda Island, leaving only 1,100 feet between them, and 700 feet between the 18-foot curves with a maximum depth of 38 feet. A line of shoals extends from this point almost to Matagorda Peninsula, 3 miles distant.

The depth over the bar at the last survey was about 9 feet, but it has fluctuated in the last 60 years between 7 and 9½ feet, once even reaching 13 feet. The lack of stability in the channel depth over the bar is shown by the fact that it was 9 feet in 1853, 13 feet in 1854, and 8 feet in 1856.

Matagorda Bay is the largest single bay on the Texas coast, and is liable to severe storms. Including Lavaca Bay it covers an area of over 400 square miles. Various efforts have been made to establish a town on its western shores near Deep Water, but they have all been abandoned. Indianola in 1870 had a population of 1,900, and it was a port of entry with a railroad communication with the interior. In 1875 it was submerged and a large part of it swept away with great loss of life, and in 1886 it was entirely destroyed by a storm. Since then it has been abandoned and the railway taken up. Matagorda is now the only town on the entire bay, and it is situated on the shallow eastern part of the bay 35 miles from the entrance, without any sea trade or prospect of any, and with a population of only 450.

The United States began the improvement of this pass in 1880, but the funds were supplied so inadequately and so irregularly that no good has been accomplished, and if the improvement is to be continued it can be prosecuted most economically by abandoning the site of the work already done. It has been estimated by Maj. O. H. Ernst, the officer lately in charge of the district, that a single jetty on the south side of the channel, extending to the 18-foot curve, will cost nearly $4,000,000, on account of the enormous cost of getting stone to this point, and it will probably, but not certainly, secure and maintain a 12-foot channel. Major Ernst in his report expresses the opinion that "the improvement of this entrance is the most uncertain and difficult undertaking that has been projected upon the Texas coast," and in this opinion the Board coincides. No appropriation was made by the last Congress for continuing this work.

SABINE PASS.

This name is applied to the outlet of Lake Sabine, which lies upon the boundary between the States of Louisiana and Texas. The lake is about 15 miles long and 8 miles wide. It is a shallow body of water, having an average depth not exceeding 7 feet, and has for its principal tributaries the Sabine and Neches rivers. The pass from the lake to the Gulf of Mexico is nearly 7 miles long by the channel, and its width varies from about one-third to 1½ miles. The country along the coast and bor-

dering on the pass and Lake Sabine is very low, usually not more than 2 feet above mean low-water level, though some places are found within a few miles having elevations of 3 to 5 feet.

The land is marshy and subject to frequent overflow, and the only suitable places for habitation are upon the small mounds and ridges.

On the west bank of the pass, at a distance of more than 4 miles from the Gulf, lies the small village of Sabine Pass at the terminus of the East Texas Railroad, which crosses and is tributary to the Southern Pacific Railroad at Beaumont, on the Neches River. Most of the water in Sabine Pass is comparatively shallow, but there is a channel averaging about 500 feet in width, and having a depth exceeding 18 feet through nearly all the pass, except for an interruption near the oyster beds, more than 3 miles from the coast, where the chart shows but 17 feet. Over more than 3 miles in aggregate length the channel has a depth of 24 feet, and more than 2 miles of the length has a depth of 30 feet or more. These greater depths are divided into nearly equal parts by the shoal already mentioned. The areas of deep water are given by Major Ernst as follows:

	Acres.
Area of 24 feet or more	100
Area of 30 feet or more	63

The bar at the mouth of the pass differs somewhat in material from the similar formations, which are characteristic of this coast. The bar is mainly composed of a soft alluvial mud upon which, it is reported, vessels have sometimes been stranded without receiving material injury. The mud has been ascertained by examination to extend to a depth of more than 30 feet below mean low-water level. A formation peculiar to this part of the Gulf coast is found in a submerged ridge, indicated on the general chart as Sabine Bank, at a distance of about 12 miles from shore. The ridge is nearly parallel to the coast line, and for a length of 10 or more miles the depths of water over the ridge in the shoalest places are but about 18 feet. The Board has been informed that the effect of this ridge is to reduce the force of the seas upon the shore.

In 1882 a project was adopted for improving the bar at the mouth of the pass, the object being to obtain a channel having a depth of 20 feet in the middle to connect the water of that depth inside with the deep water of the Gulf; the work was to be accomplished by means of two jetties extending from the shore across the bar and dredging between them, if found necessary.

Added to the effective factors which are common to all the harbors on the coast in maintaining the channels, Sabine Pass has the currents increased by the outflow of the Sabine and Neches rivers. These combined forces under natural conditions have maintained a cross-section which may be given as 27,744 square feet, that being the mean sectional area of two of the narrower places in the pass where the depths of water are greatest. (Report of Chief of Engineers, 1882, page 1432.)

Work upon the project was commenced in 1883 and has been continued periodically as appropriations became available. The east jetty has been completed to a distance of a little more than 3 miles from shore, and the west jetty has been completed to a distance of nearly 1½ miles, besides laying the foundations about 1½ miles farther.

As a result the channel over the bar had been increased from less than 7 feet to 10½ feet at the date of the latest report received. The expense of completing the project, as estimated by the Engineer officer in charge, is $1,801,250.

ARANSAS PASS.

This is the entrance to Aransas Bay, which has an area of about 80 square miles, and is connected by very shoal water with Corpus Christi Bay on the one side and Mesquite, St. Charles, and Copano bays on the other. These connected bays, together with Aransas Bay, have a united area of about 350 square miles. The pass has for many years been moving in a southerly direction until it is now 3 or 4 miles southwest of the extreme southern end of Aransas Bay. The annual rate of movement from 1868 to 1878 was about 260 feet, but since 1882, when the head of Mustang Island to the south of the pass was temporarily protected, the rate had been reduced to 70 feet. This protection has now been constructed of stone in such a manner that farther movement of the pass is not to be expected.

The cross-section at the gorge of the pass between St. Joseph's Island on the north and Mustang Island on the south, has varied about 50 per cent. in the last twenty years, as shown by the five surveys taken during that time, the earliest survey in 1868 showing a cross-section of 18,412 square feet, and the latest one in 1887 giving a cross-section of 17,250 square feet, while the survey of 1871 gives a cross-section of 26,274 square feet. The widths have varied from 1,785 feet to 3,040 feet, and the maximum depth from 27 feet to the present depth of 38 feet.

The area of the harbor included within the 24-foot curves is now about 60 acres, 19 acres of which have a least depth of 30 feet.

The channel across the bar has a least depth of 8½ feet at present, having varied in the past from 7 to 9½ feet.

The approved project for improving this pass provides for two jetties of stone or concrete 2,000 feet apart, built out to the 20-foot curve, at an estimated cost, in addition to past appropriations, of $1,471,000. It is anticipated that a depth of at least 20 feet will be secured and maintained by these jetties. Though the outer slope of the bar is quite steep, no project has ever been made to secure 30 feet depth at this pass.

On Aransas Bay, 13 miles from the pass, is the town of Rockport, the terminus of the San Antonio and Aransas Pass Railroad, which also has a terminus at Corpus Christi, on the bay of the same name. Corpus Christi, with 5,000 inhabitants, is the terminus also of the Mexican International Railroad. When the pass is improved, it is expected that a railroad will be constructed from Corpus Christi down to Mustang Island and along that island to its head and across to Harbor Island, opposite the pass. Mustang Island is quite high, at points reaching, it is said, an elevation of 50 feet, which makes it peculiar among Texas islands. The shores of Corpus Christi Bay are also quite high, and those of Aransas Bay are not exposed to inundation. When the pass is improved the channel connecting Aransas and Corpus Christi bays will doubtless also be improved eventually to obtain a depth of approximately 14 feet, which is the prevailing depth of Corpus Christi Bay.

GALVESTON ENTRANCE.

About 10 miles southwest of this entrance are the Deer islands, at the east end of West Bay, which may be taken as the dividing line between the tidal basins tributary to San Luis Pass on the south and Galveston entrance on the north. Galveston Bay, or the tidal basin tributary to Galveston entrance, covers an area of about 455 square

miles, and is divided into the East, Upper, and Lower bays by a line of reefs, which, in its natural condition, had a channel through it only 4 feet deep. The East Bay, comprising the portion east of Hanna's Reef, extends 23 miles from the entrance, covers about 70 square miles, and is very shallow, with an occasional sounding of 8 feet. The Upper Bay, comprising the portion north of Red Fish Bar, extends to about 30 miles from the entrance, and covers an area of about 250 square miles, nearly one-fourth of which has a depth of from 10 to 11 feet. The Lower Bay, which is, strictly speaking, Galveston Bay, comprising all the bay between the entrance and the line of reefs, covers an area of about 135 square miles, no point of which is more than 12 miles from the entrance. Within 3 or 4 miles of the entrance the water is quite deep, but beyond that it rarely reaches a depth of 9 feet in the Lower Bay.

The bay on the north of the entrance is separated from the Gulf by Bolivar Peninsula, which is about 23 miles long, and south of the entrance by Galveston Island, which extends about 28 miles to San Luis Pass. Both Bolivar Peninsula and Galveston Island are narrow and rise very little above storm tides. The northern portion of the island between the city of Galveston and the entrance is so low as to require artificial protection to prevent the formation of a shallow channel across it.

Just inside the entrance the channel is divided by Pelican Shoal, including Pelican Island and Pelican Spit, the main or Bolivar channel lying just north of the shoal and Galveston channel lying east of it. This shoal covers an area within the 6-foot curve of 8 square miles, of which about 80 acres are in Pelican Spit and 720 acres in Pelican Island.

The Galveston Channel, outside the wharves, is only about 700 feet wide, lying between Pelican Shoal and Galveston Island, and extending about 3 miles southwest from the entrance. Near the entrance is a bar which in 1867 had only 9½ feet of water on it, but which since its improvement has about 21 feet at low water. In 1841 this bar did not exist, as there was a depth of 30 feet from the Galveston wharves out to where the water begins to shoal near the outer bar. This inner bar was caused apparently by storms washing away a part of the northeastern end of Galveston Island, and has been easily improved. The northeastern end of the island adjacent to this bar for more than 1½ miles is so low as to be washed over in severe storms, and is constantly liable to be cut in two. The channels so formed across this part of the island by extraordinary gales are, however, very shallow and eventually disappear. The present plan of improvement will put an end to this danger by connecting the shore end of the southern jetty with the shore protection built by the citizens of Galveston. When the entrance is improved this land will be valuable for commercial purposes and will doubtless be thoroughly protected from overflow.

The entire area inside the outer bar, containing a least depth of 30 feet, is 460 acres, and there are 1,300 acres with a least depth of 24 feet, but these areas can scarcely with safety be referred to as Galveston Harbor without explanation, because over 500 acres of the 1,300, with a least depth of 24 feet, lie outside the gorge.

The outer bar is about 4 miles beyond the gorge of the entrance, with a channel across it carrying 13¼ feet at mean low water, the natural depth before the improvement was commenced having been about 12 feet. The gorge has a width of about 8,200 feet, one-half of that width lying between the 18-foot curves of the banks. The 24-foot curve ex-

tends gulfward from the gorge a distance of 2 miles, and towards the inner harbor along Bolivar Channel a distance of 2 miles, and along the Galveston Channel about 4 miles. Thus there is formed a well-protected inner harbor and an excellent roadstead, a large part of which is outside the gorge. This roadstead is protected at present by the bar, which serves as a low dike, but which will be removed to a depth of 30 feet in the channel when the present project is completed. On the other hand, the roadstead will receive additional protection from winds in certain directions owing to about 5 miles of jetty on each side, which will extend a mile beyond the bar and rise to about 4 feet above ordinary high tides.

The present cross-section at the gorge has an area of about 160,000 square feet and a maximum depth of 50 feet. Lieut. W. S. Stanton, U. S. Corps of Engineers, in his report of the survey of 1868 (Report of Chief of Engineers 1868, p. 507), gives the combined cross-section of the Galveston and Bolivar channels after they are separated by Pelican Spit as 147,742 square feet. Making all reasonable allowances for the amount of cross-section not included by Lieutenant Stanton in these two channels, it does not appear that there has been any diminution in the cross-section at the gorge in the last twenty years.

There was appropriated for Galveston Harbor prior to July, 1886, $1,478,000, the first appropriation of $25,000 being made in 1870. The city of Galveston also furnished in 1883 $100,000 for continuing the work, as Congress failed after 1882 to make further appropriations until August, 1886. Whatever might have been the result had the whole amount of money been appropriated at one time, so that the work could have been pushed with energy and damages repaired at once, it is certain that the effort to accomplish a great work with inadequate means resulted in the loss of a large part of the work done. After the appropriation of 1882 it was four years before another appropriation was made. Work was then resumed upon the plan of building a stone jetty on each side of the channel, these jetties to be slightly converging, so as to be only 7,000 feet apart at their outer ends, which are to be at the 30-foot curves, about 5 miles outside the gorge. The tops of the jetties are to be 5 feet above mean low water, and their combined length is estimated at 54,000 feet, about 10,000 feet of which will be outside the present crest of the bar. The jetties are to be of stone and concrete, with a top width of from 12 to 24 feet. The approved project gives the details as follows:

> The following is in general terms the cross-section of the proposed jetties. It should be modified in details when experience acquired on this unstable bottom shows it to be necessary. In the shoal water it is very possible that it may be somewhat reduced. (From the bar to the 24-foot curve it may be necessary to protect the foundation by a layer of heavier stones, and this is included in the estimate.) Top of jetties to be 5 feet above low water, but to slope to level of ground at their inner ends. Foundations to be a brush mattress 3 feet thick, covered at once by 4 feet of rubble, with widths increasing from 60 feet near the shore to 90 feet at the bar and 100 feet beyond. Jetties to be 12 feet wide on top, and of rubble stone, with side slopes of 1 on 1 out to the crest of bar, except for about 10,000 feet inside of crest, for which distance the rubble jetty is to be 22 feet wide at low-water level, and on this a concrete mass 12 feet wide is to be constructed, reaching from 5 feet above low water to 2 feet below. The rubble side slopes, from about 6 feet depth outward, to consist of heavy stone blocks, whose weight at the bar reaches 6 or 8 tons. From crest of bar to 30-foot curve, jetties to be concrete piers, their widths being 18 feet at crest of bar, 24 feet at 18-foot curve and outside of it. These piers may be built either of concrete in huge bags, as the breakwater at New Haven, England, and Aberdeen were built, or of concrete in large blocks, in either case being topped with concrete in mass. Such a concrete pier at present would be cheaper than a rubble jetty protected by heavy concrete blocks; but as it will be some years before they will be built, the question should then be

reconsidered in view of the prices then existing and of experience then gained. The new south jetty should follow the existing south jetty in a general way to utilize most economically existing work—selecting the shoalest side of any part of it for the new work there, but avoiding abrupt changes of direction in the new jetty.

The order of construction should be, first, to complete the south jetty to the crest of the bar; second, the same for the north jetty; third, carry both to the 30-foot curve.

Since carrying the south jetty out to the bar will reduce considerably the water cross-section on the bar, the velocities and depths there should be somewhat increased by that jetty alone. When both jetties are completed to the bar there is reason to believe that they will, when their full effect is produced, give depths about two-thirds of those which jetties carried to the 30-foot curve will give.

As the jetties will diminish the freedom of inflow at Galveston they will tend slightly to enlarge the San Luis Pass. It should therefore be watched.

The estimated cost of these jetties out to the crest of the bar is $3,00),000, and this amount will probably give two-thirds the depths that jetties carried to the 30-foot curve would give.

The estimated cost of jetties completed to the 30-foot curve is $7,000,000, their aggregate length being nearly 54,000 feet. This estimate supposes that the money is freely supplied. (Report of Chief of Engineers for 1886, page 1310.)

There has been appropriated $800,000 to carry out this project, leaving $2,200,000 of the estimate still required to extend the jetties to the crest of the bar, which it is expected will give a 20-foot channel. The cost of further extending these jetties to the 30-foot curve is placed at $4,000,000 in addition to the $2,200,000 required for a 20-foot channel. While a probable depth of 30 feet is anticipated from this work when completed, yet the Board of Engineers, in the report from which we have quoted, expressly disclaims any prediction of the precise depth which the jetties will maintain.

DEEP-WATER HARBOR.

The above-mentioned points comprise all on the Gulf coast of the United States at which it has been deemed practicable to construct a harbor west of 93° 30′ west longitude. The duty imposed upon this board is to determine and report which of these points is most eligible "for a deep harbor to be of ample depth, width, and capacity to accommodate the largest ocean-going vessels and the commercial and naval necessities of the country, which can be secured and maintained in the shortest time and at the least cost."

The act imposes the absolute conditions that the harbor shall be of "ample depth, width, and capacity to accommodate the largest ocean-going vessels and the commercial and naval necessities of the country," and only such harbors as can be made to satisfy these conditions are to be compared as to cost and time of construction, cost of maintenance, and eligibility.

As already stated in connection with the proposed outer harbor at Padre Island, the Board does not consider that an outer harbor will meet the wants of the country to the extent contemplated by the act under which this Board was constituted, and it is therefore assumed that the proposed harbor is to be an inner harbor.

Ample depth.—Many of the largest ocean-going vessels have a draft when loaded exceeding 26 feet, and a few even exceed 27 feet, and reach 28 feet in extreme cases. To provide for these large vessels with moderate tides, the channel should have a depth at mean low water of at least 30 feet where exposed to the action of the sea, and at least 27 feet where protected from such waves. Where the range of tide is great, less depths might be admissible, as in such cases the detention of the largest class of vessels would be but slight. In comparing the depths

of channels of entrance to different harbors, it is perhaps fairer to take the depths at mid-tide in connection with the mean range, rather than the depths at low water, and allowance must always be made for great exposure to the sea. In the recently adopted projects for the improvement of the approaches to New York, Philadelphia, and Baltimore harbors, to enable them to meet the demands of the large vessels of the present time, the low-water depth for Philadelphia (where the range of tide is 6 feet) is to be 26 feet, or one foot less than for Baltimore (where the tide ranges only 1 foot 6 inches), but its high-water depth will be 32 feet, or 3 feet 6 inches greater than for Baltimore; while New York entrance, which is exposed to the sea, instead of being thoroughly protected, as for Philadelphia and Baltimore, has a depth of 30 feet at low-water and 34 feet 8 inches at high tide.

Along the coast of Texas the tides are far less regular, and their ordinary mean range, being only 1.1 feet, is much smaller than upon our eastern coast. This lack of reliability of the tide combined with its smallness, averaging only eight-tenths of a foot for half of each month, makes it of little practical value. The entrance to a deep-water harbor on the Gulf will necessarily be exposed to severe storms.

In consideration of the above facts the Board is of opinion that the channel depth in the entrance to a deep-water harbor on the northwest coast of the Gulf of Mexico should not be less than 30 feet at mean low water, in order to accommodate the largest ocean-going vessels.

A portion of the harbor should have as great depth as the entrance, because while not equally exposed, yet the inner harbor is liable occasionally to extreme low water caused by long continued gales from the land driving the water out of the harbor and leaving the vessels exposed to the danger and inconvenience of this diminished depth. Under such conditions of reduced depth vessels of extreme draft reaching the entrance would be compelled to wait outside.

Ample width and capacity.—The entrance will not, in the opinion of the Board, have ample width to accommodate the largest ocean-going vessels and the commercial necessities of the country if the width between the jetties is less than 2,000 feet, and the width of the 30-foot channel less than 600 feet, which is scarcely more than the length of the largest modern vessels. If we suppose the water to shoal uniformly from the edges of this deep channel so as to give a depth of only 6 feet at the jetties, its cross-section would have an area of 43,000 square feet, which it is thought fairly represents the area of cross-section of the minimum channel of entrance just described. The entrance to New York harbor is to have the maximum depth for a width of 1,000 feet, and even as protected a river as the Delaware, 100 miles from the sea, is to have its channels of maximum depth for a width never less than 600 feet.

The harbor differs from the entrance in its requirements as to width and capacity, in that the width and cross-section of the entrance is almost independent of the number of vessels visiting the port, while the width required in the harbor is partially and the capacity entirely dependent upon the extent of the commerce of the port. Upon the opening of a port for deep-draught vessels a very small capacity of inner harbor of maximum depth would be required, while an entrance of suitable cross-section, as already described, would be demanded at once. Any great increase of the commerce would require a corresponding enlargement of the capacity of the harbor without necessitating a change in the entrance. The entrance to the harbor, therefore, must at the begin-

ning be made of ample depth and width, while the harbor itself may be gradually enlarged to meet the increasing demands of commerce. What harbor capacity may be ultimately required by commerce no one can foretell; it will in great part have to be provided by dredging at whatever point is selected, and the cost of providing this additional area would differ so little at the various points on the Texas coast as not to seriously affect the question under consideration.

A large area for anchorage is not demanded so much as abundant dock facilities with convenient approaches. If a suitable entrance and convenient approaches were secured, the construction of the docks at private and corporate expense would keep pace with the increasing demands of commerce.

In order to allow the fullest scope to private enterprise and at the same time to avoid interference with the future developement of the harbor, prudence demands the early establishment of harbor lines at the selected port, under authority now provided by law.

The conditions, then, that must be fulfilled by any one of the points described in order that it may be worthy of consideration as a deep-water harbor, are that it shall be an inner harbor to which an entrance having a clear width of not less than 2,000 feet, a cross-sectional area not less than 43,000 square feet, and a depth of not less than 30 feet for a width of 600 feet, can be secured and maintained.

Under these conditions, and for reasons previously stated, the question of an outer harbor at Padre Island can be dismissed from consideration.

The Board has found no point on the coast where it can recommend the construction of a harber, save at points where there are natural passes or outlets.

The mouth of the Brazos River, Corpus Christi Pass, and the entrance of Brazos Santiago, are all far too small. The largest sectional area maintained by natural causes at either of these places is less than one-fourth the amount which the Board considers necessary for the purpose required.

San Luis Pass has a larger cross-section than either of the three entrances above mentioned, but it is less than half the size already indicated as a minimum. It has never been improved by the Government and it possesses no special advantage that is not held in a greater degree by Aransas Pass or Sabine Pass, both of which have many valuable features not possessed by San Luis Pass. The Board does not, therefore, deem San Luis Pass as requiring any further consideration in this connection.

Pass Cavallo, as a whole, has a sufficiently large sectional area if properly improved, but its improvement is so difficult that it has been estimated by the officer recently in charge that it will cost $4,000,000 to obtain a 12-foot channel over the bar, while the estimated cost of completing works designed to obtain a 20-foot channel at three other points varies between 40 and 55 per cent. of that amount.

There can be no doubt that works sufficient to obtain a depth of 30 feet at Pass Cavallo would involve an expenditure for construction and maintenance far exceeding that at either of the three places just mentioned, and the harbor when completed would be more exposed to waves from the bay.

The three points remaining to be considered, Sabine Pass, Aransas Pass, and Galveston Entrance, are all worthy of improvement, and are now being improved under projects for obtaining a probable depth of 20 feet at Sabine Pass and Aransas Pass, and 30 feet at Galveston

Entrance. At any one of these points an excellent harbor can be made.

Sabine Pass has the advantage of a softer bar than at the other points, of having its entrance better protected owing to the direction of the coast line and to the presence of Sabine Bank, and of being the outlet of the two large rivers draining the extensive timber region of eastern Texas. It has the disadvantage of having the land in the vicinity generally not higher than about 2 feet above low water, and of not being so conveniently situated as Galveston or Aransas Pass for a deep-water harbor to accommodate the commercial necessities of the large extent of country naturally tributary to a port on the northwest coast of the Gulf of Mexico.

Aransas Pass has the advantages of the shortest distance across the bar to deep water of the Gulf, high ground on Mustang Island south of the pass, and a harbor at present well protected from the waves of the Gulf and Aransas Bay. It is well situated as a commercial port for a large section of our own country as well as for a portion of Mexico. The railroads already constructed connect Aransas and Corpus Christi bays with Mexico and with the general railroad systems of Texas.

The harbor at Aransas Pass has the disadvantage of a smaller area of deep water than either Sabine Pass or Galveston Harbor. The protection of this harbor from storms on the Gulf is made by the low point of St. Joseph's Island, which will need protection to stop the movement of sand. The deep water lies between this sandy point and Harbor Island, which is but little more than a marsh, being composed nearly all of mud, with a little sand and shell, and subject to overflow in storm tides. A great part of Harbor Island is less than 2 feet above the level of mean low water, and the extreme elevation can hardly be as great as 3 feet. Mustang Island, though high, is not adjacent to the long channel of deep water which will of necessity form the harbor at Aransas Pass.

Galveston, including entrance and harbor, has the advantage of the largest area of deep water in addition to the open roadstead. It is most central as a port for the large area of Texas and other States which already need and ultimately must have a deep harbor upon this coast. Galveston has far better railroad facilities than are found at the other points, and it has an active commercial city of about 50,000 inhabitants.

Galveston has the disadvantage of the longest distance for which works must be constructed to reach the deep water of the Gulf.

In a comparison of locations, therefore, Sabine Pass is best situated for the large lumber region drained by the Sabine and Neches rivers, but it is nearest to New Orleans and the great artery of commerce, the Mississippi River. Aransas Pass is most convenient to the southern part of Texas and to Mexico, and Galveston is most central for a general commercial port.

The Board has already stated that in deciding the question of a location for a deep-water harbor a comparison of expense can not be considered, save between harbors which are found to fulfill the requirements of ample depth and capacity which are imposed by the act of Congress as prime conditions.

These conditions, as definitely stated by the Board, are, that an entrance shall be maintained with a continuous width of at least 2,000 feet, and a channel depth of 30 feet over a width not less than 600 feet, the two involving a sectional area of about 43,000 square feet.

Sabine Pass has a cross-section at the gorge of 27,376 square feet,

and at Aransas Pass the cross-section of the gorge was but 17,250 square feet in 1887. The sectional area at Aransas Pass has varied considerably, having been 18,412 square feet in 1868, 26,795 in 1871, and since that date constantly decreasing to the area first given.

At Sabine Pass, where it is comparatively protected, the natural conditions have not maintained a channel of 22 feet depth over a greater average width than 500 feet, and it is not reasonable to expect that a channel of the dimensions necessary for a deep-water harbor can be secured and maintained without extensive and almost constant dredging. Such dredging would entail a large annual expenditure, for which the Board can have no data sufficient to make an estimate.

The question of maintaining a channel at Aransas Pass by dredging would doubtless assume at least as great proportions as at Sabine, owing to the smaller natural sectional area.

It should also be mentioned in this connection that the maintenance of a channel of such depth by dredging or by other mechanical means in situations necessarily much exposed to the sea and to passing vessels is not only attended with great expense, but from probable lack of constant funds and other causes would necessarily be uncertain and unsatisfactory.

The sand is drifted by wind and wave, the resultant movement being to the southwest along this entire coast, and it has a tendency to fill up the passes. If the southerly bank yields, the pass is moved ultimately to a position where the force of currents from storm tides is reduced; the pass then diminishes in size until it becomes like Corpus Christi Pass or Cedar Bayou, almost obliterated, or even like Boca Chica, closed entirely.

A great accumulation of water in the bays after a continued gale from the Gulf, when driven out through the pass by the returning gale from shore, causes violent currents, which scour out the accumulated sand and thus preserves the opening. The size of the channel that can be thus preserved by the currents when held in place by jetties can only be approximately estimated from that which has been maintained in the past at points where the width conformed nearly to the width required between the jetties. A channel 600 feet wide and 30 feet deep, exclusive of the shallower water which must naturally obtain on either side, has a larger sectional area than the latest given for Aransas Pass.

It seems unreasonable to demand of any system of permanent improvement that it shall maintain a cross-section in the channel between jetties two-and-a-half times, or even one-and-a-half times, as great as nature has been able to maintain in the gorge where currents are strongest. These would approximate the demands upon Aransas and Sabine passes respectively, in order that they should maintain the minimum entrance for a deep-water harbor of the depth and capacity required.

In the opinion of the Board it is possible to maintain an entrance of ample depth and width at one point on this coast without much if any dredging for maintenance. The Galveston entrance at Bolivar gorge is 8,200 feet wide, one-half of the width lying between the 18-foot curves, giving a channel between the curves at this point about 4,000 feet wide, with a maximum depth of 50 feet, a mean depth of 30 feet, and a cross-section of 120,000 square feet; the width between the 30-foot curves is about 1,500 feet. The entire cross-section of Bolivar gorge is 160,000 square feet, which is 6 times greater than that of the gorge at Sabine Pass and 9 times greater than the cross-section of the gorge at Aransas Pass.

If by the construction of jetties there could be maintained between them a channel anything like the one now preserved by nature at the gorge of the entrance at Galveston, it would more than meet all the requirements of commerce and of the act under which this Board was constituted. But if channels between jetties were maintained at Sabine and Aransas passes fully equal to those now preserved at their gorges, these channels would be wholly inadequate to meet the demands of the act of Congress. At the gorge at Galveston nature has preserved a channel about 6,000 feet wider and more than 10 feet deeper than at either of the other points, and whatever results may be attained at the latter places by works of improvement, it is reasonable to expect that still greater results can be obtained by improvements at Galveston.

The act of Congress in compliance with which this report is made imposes upon the projected harbor the severest requirements, and as the Board has grave doubts of the possibility of their fulfillment at the other points, it is forced to decide in favor of the one which promises the greatest results.

The Board therefore deems Galveston Harbor the most eligible point on the northwest coast of the Gulf of Mexico west of 93° 30′ west longitude for a deep harbor fulfilling all the requirements of the act under which it was constituted, this being the only point fulfilling these conditions.

The cost of constructing the jetties at Galveston entrance out to the 30-foot curve, as estimated by the Board of Engineers in 1886, is $6,200,000, in addition to appropriations already made. This is based upon the condition of continuous work under adequate appropriations, and does not include the cost of dredging in the entrance, if any should be required, or of any dredging in the harbor, which latter will certainly be required to meet the commercial necessities of the deep-water harbor of the future. The dredging in the harbor can not be estimated until harbor lines are established, which the Board considers beyond its province.

If the jetties have sufficient time to act before the full depth is required in the channel of entrance, storm-tides will scour out the channel except in places where hard material occurs. When the channel is once formed it is not believed that there will be deposits in advance of the jetties to such an extent as found at the mouths of silt-bearing streams.

The question of the "least time" necessary to obtain a deep-water harbor has been disposed of by the fact that the Board deems that one point only can satisfy the necessary conditions for a deep-water harbor as contemplated by the act of Congress. In order to obtain a deep channel of entrance in the least time the entire amount estimated to complete the jetties, namely, $6,200,000, should be appropriated at the earliest practicable day. It would not probably delay the work if only one-third of this amount were available the first year, another third the second year, and the balance the third year. If the funds were thus available the work could be prosecuted with the utmost vigor and the jetties completed within three or four years.

The fact that the entire amount to complete the work had been appropriated would give business men confidence in the early completion of the improvement, and plans would doubtless be adopted to increase the railroad facilities and develop the resources of the harbor so that commerce might avail itself of the advantages of the deep-water harbor as soon as a suitable channel of entrance was obtained.

While the Board has thus been forced to conclude that the harbor of Galveston is the only one which may be made to fulfill all the require-

ments of the act of Congress, it does not thereby desire to intimate that excellent harbors for refuge and commerce may not be made at other points in less time and at less expense than will be ultimately required at Galveston.

The estimated cost of completing the approved projects for obtaining a probable depth of 20 feet is $1,801,250 for Sabine Pass and $1,471,293.72 for Aransas Pass. It seems probable that the capabilities of these harbors may be somewhat increased in future at an additional expense.

These harbors, however, when given the depth anticipated from the present projects, will serve the demands of a very extensive commerce. The country tributary to all these ports is rich in resources and is being developed rapidly in population and productions, and the time is near at hand when more than one good harbor will be required upon this extended coast.

The Board, therefore, can not dismiss the subject without commending the harbors at Sabine and Aransas passes as being worthy of great consideration and of vigorous prosecution of the works of improvements to obtain the results which are expected from the completion of the present projects.

Respectfully submitted.

HENRY M. ROBERT,
Lieut. Col. Engineers.
G. L. GILLEPSIE,
Lieut. Col. Engineers.
JARED A. SMITH,
Lieut. Col., Corps of Engineers.
Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

V 2.

IMPROVEMENT OF SHIP-CHANNEL IN GALVESTON BAY, TEXAS.

The present project for this improvement, adopted in 1871 and modified in 1877, consists in excavating a channel at least 12 feet deep and with a width at bottom of 100 feet through Galveston Bay from Bolivar Channel to Morgan's Cut, a distance of about 18.9 miles, the average natural depth in the bay on the line of this channel being about 8½ feet at mean low tide. This channel is one link in a water-way connecting Houston with the Gulf of Mexico, of which the other links are the private works at Morgan's Point and its approaches on the bay side, the San Jacinto River, and Buffalo Bayou. The works at Morgan's Point comprise Morgan's Canal and Morgan's Cut. Morgan's Canal is a cut through a Peninsula called Morgan's Point; it connects the San Jacinto River with Galveston Bay. Morgan's Cut is a dredged prolongation of the canal extending out into Galveston Bay for a distance of 5 miles. Both the canal and cut were excavated by the Buffalo Bayou Ship-Channel Company, a corporation chartered by the State of Texas. This company agreed, in 1881, to surrender to the United States its work at Morgan's Point, together with its charter and rights under it, upon the completion by the Government of the ship-channel in Galveston Bay. The acts of Congress appropriating money for the work read, "Improving ship-channel in Galveston Bay, Texas, from Morgan's Cut to Bolivar Channel." For more detailed information as to the work done by the Buffalo Bayou Ship-Channel Company attention is invited to Appendix T 2 to the Annual Report of the Chief of Engineers for 1887 and to Appendix V 2 to the Annual Report for 1889.

The excavation by the United States of a channel up to Morgan's Cut was completed by the 20th of July, 1889, and the company was then called upon to execute its agreement of February 14, 1881, to transfer to the United States its works at Morgan's Point. The claim for compensation advanced by the company, and the position of the United States Government in the matter, appear clearly shown by the correspondence printed on pages 1555–1557 of Appendix V 2 to the last Annual Report. The work of dredging, completed July 20, 1889, was done by contract with George C. Fobes & Co., dated February 2, 1889, under the appropriation in the rivers and harbors act of Congress of August 11, 1888. The bid is tabulated on page 1551 of the Annual Report for 1889. Quantity of material removed during the past fiscal year, 19,829.5 cubic yards. Marking the excavated channel by beacons, "so as to enable navigators to find the same without difficulty," was ordered by act of Congress approved August 5, 1886, and continuance of the same by the act of August 11, 1888.

At the close of the last fiscal year the erection of beacons had not progressed to any great extent, and the work was retarded during the past fiscal year owing to various causes detailed in the report herewith of Mr. E. M. Hartrick, assistant engineer. For description of beacons attention is invited to that report and also to the sketch herewith. The beacons were built and placed by hired labor. They had to be kept in repair and, in some cases, renewed during the year.

As regards the permanence of the dredged channel, the last annual report states as follows:

A resurvey of the entire length of the channel was made in June. It shows a marked deterioration of the channel through the lower bay, where the greatest length of time has elapsed since the work was done. Considering the portion of the channel, 9.93 miles in length, extending from Bolivar Channel to Redfish Bar, the average length of time which had elapsed since the execution of the work was ten months. The average depth of the bay before excavation was 8.63 feet. The average depth of the channel after excavation was 13.15 feet, making an average depth of excavation of 4.52 feet. The average depth of the channel was found in June to be 11.61 feet, which shows an average fill of 1.54 feet, or 34 per cent., in ten months. In my annual report for 1887 I stated that "if the channel between Bolivar Channel and Redfish Bar be maintained at the full depth of 12 feet it will require the removal each year of not less than 30 per cent. of the amount originally excavated." (See Annual Report Chief of Engineers for 1887, page 1420.) These views have been fully confirmed.

In the upper bay the average period which had elapsed since the execution of the work was in June only two months, and no important deterioration was detected by the survey.

An examination of the dredged channel made in June of this year by Lieutenant Langfitt and Mr. Hartrick, shows that of the depth of excavation remaining in June, 1889, in the lower (from Bolivar Channel to Redfish Bar) 40 per cent. had filled up during the past twelve months, and that since the completion of the work in the lower bay, a period of about two years, 60 per cent. had filled up.

In the upper bay (from Redfish to Morgan's Cut), during the past fourteen months, there has been a fill of 24 per cent. of the total quantity excavated. Redfish Cut has not materially changed since the survey of June, 1889.

The ruling depth from Bolivar Channel to Morgan's Cut is now 10 feet at mean low tide, the average depth being somewhat more. The results appear to bear out the statement in the Annual Report for 1887, that, if the channel between Bolivar Channel and Redfish Bar be maintained at the full depth of 12 feet, it will require the removal, each year, of not less than 30 per cent. of the amount originally excavated. It can not, therefore, be said that this work is capable of permanent completion.

The strong freshet of the 3rd to 6th of April pretty thoroughly de-

stroyed the revetment of Morgan's Canal which had been constructed by the Buffalo Bayou Ship-channel Company, besides resulting in deterioration, as reported, of the navigation of the canal and, probably, of that of the cut, though to what extent is not now known to this office. No commercial statistics can be given to apply to this work. It is believed, by many of the best-informed men of Houston, that the advantages to be derived from enabling sea-going ships to reach Buffalo Bayou will be vastly greater than the cost of making and maintaining the channel. The annual report from Buffalo Bayou gives as full statistics of the freight carried upon that stream as could be obtained. It is carried in barges drawing 5 feet when fully loaded and towed by tugs drawing 7 feet and less. These cross Galveston Bay, but the depth of water is already sufficient for them. A large proportion of this freight would be loaded directly upon sea-going ships if they visited Houston. One item of shipment, by water down Buffalo Bayou from Houston during the past fiscal year was 243,100 bales of cotton valued at about $13,370,500.

The estimate, $200,000 here submitted for continuing the work during the year ending June 30, 1892, is the amount required to complete the original excavation and maintain it one year. With this sum and with regular adequate appropriations thereafter, the work can be maintained.

Total expended on this improvement to June 30, 1889	$488,944.24
Total expended during fiscal year ending June 30, 1890	40,869.98
Original estimated cost of this work as revised in 1888	740,108.22
Aggregate amount appropriated to July 1, 1890	546,500.00
Amount expended to July 1, 1890, including outstanding liabilities	529,814.22
The amount required for maintenance after the completion of the original excavation (annually)	80,000.00

The work is located in the collection district of Galveston. The light-houses on or near the line of the work are at Bolivar Point, Fort Point, Half-moon Shoal, and Redfish Bar. The amount of revenue collected at the port of Galveston during the fiscal year ending June 30, 1890, was $131,613.17.

ABSTRACT OF APPROPRIATIONS MADE BY CONGRESS FOR IMPROVING SHIP-CHANNEL IN GALVESTON BAY, TEXAS.

By act approved—	
March 3, 1875	$25,000
August 14, 1876	72,000
June 18, 1878	75,000
March 3, 1879	80,000
June 14, 1880	50,000
March 3, 1881	50,000
By act passed August 2, 1882	94,500
Ay act of August 11, 1888	100,000
Total	546,500

Money statement.

July 1, 1889, amount available		*$32,730.24
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889, and exclusive of payments made on contracts in force July 1, 1889	$14,916.78	
July 1, 1890, outstanding liabilities	1,127.68	
		16,044.46
July 1, 1890, balance available		16,685.78
Amount appropriated by act of September 19, 1890		40,000.00
Amount available for fiscal year ending June 30, 1891		56,685.78

* On July 1, 1889, the amount to complete contract then in force was estimated at	49,905.71
But the contract was completed for	24,815.52
Hence the balance available July 1, 1889, is increased by	25,090.19

Amount that can be profitably expended in fiscal year ending June 30, 1892	$200,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

REPORT OF MR. E. M. HARTRICK, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., April 30, 1890.

SIR: I have the honor to submit the following annual report of operations for improving the ship-channel in Galveston Bay, Texas, during the fiscal year ending June 30, 1890.

At the end of last fiscal year the contractors, Messrs. Geo. C. Fobes & Co., had not completed their contract of February 2, 1889, although they had notified the assistant engineer to that effect, being under the impression that they had complied with the specifications and completed the contract on June 22, 1889; but on the final survey and inspection it was found that a 12-foot depth could not be maintained for the last 6,225 feet. The contractors then requested an extension, which being granted, the work was finally completed and accepted July 20, 1889.

SUMMARY.

Advance of completed channel this year 9,346 feet=1.8 miles

Excavated by each dredge during the year:

	Cubic yards.
No. 5	13,742.9
Col. Craighill	6,086.6
Total this year	19,829.5
Excavated in advance of completed channel last year	168,468.5
Total	188,298.0

Accounted for as follows:

Allowed contractors this year	165,107.0
Deductions	23,191.0
Total	188,298.0

The average number of hours actual dredging, etc., for the two dredges, *No.* 5 and *Col. Craighill*, has not been tabulated for this year, as the short time, twenty days, would not give reliable data on account of the dredges being partially dismantled and the crews discharged on the 22d of June, the contractors believing they had completed their contract on that date. They reorganized afterwards and went to work on the 2d of July, 1889. By referring to the annual reports of June, 1888, and 1889, the average of each dredge's work, etc., can be examined, and deductions made therefrom.

ERECTION OF BEACONS MARKING THE SHIP-CHANNEL.

At the end of last fiscal year the erection of beacons marking the ship-channel through Galveston Bay had not progressed to any great extent. The work was retarded this year by the transfer of the schooner on the 1st of September, 1889, to Trinity River Improvement, and it was not until October 29 that the final report was submitted on the work accomplished and the material used. In the trigonometrical location of the beacons, delay occurred, as all of the old primary triangulation stations had to be renovated, some renewed, and two re-located, and the time of the year was also not favorable for observations on account of boisterous weather, fog, mist, and haze. The beacons are located from Galveston Harbor base, and can be used hereafter in surveys and the laying out of work in connection with the excavation and improvement of channel.

The force employed on the work was as follows: One foreman, who was also master of schooner; one ship carpenter, one cook, six laborers and seamen; and the plant consisted of one schooner; one pile-driver, hand-power; one force-pump, one yawl, with tools, etc., for painting, coal-tarring, and concreting, also tender tug *Molyneux*, when not used on surveys, inspection of tide houses, and Trinity River Improvement.

ELEVATION AND PLAN

SHOWING

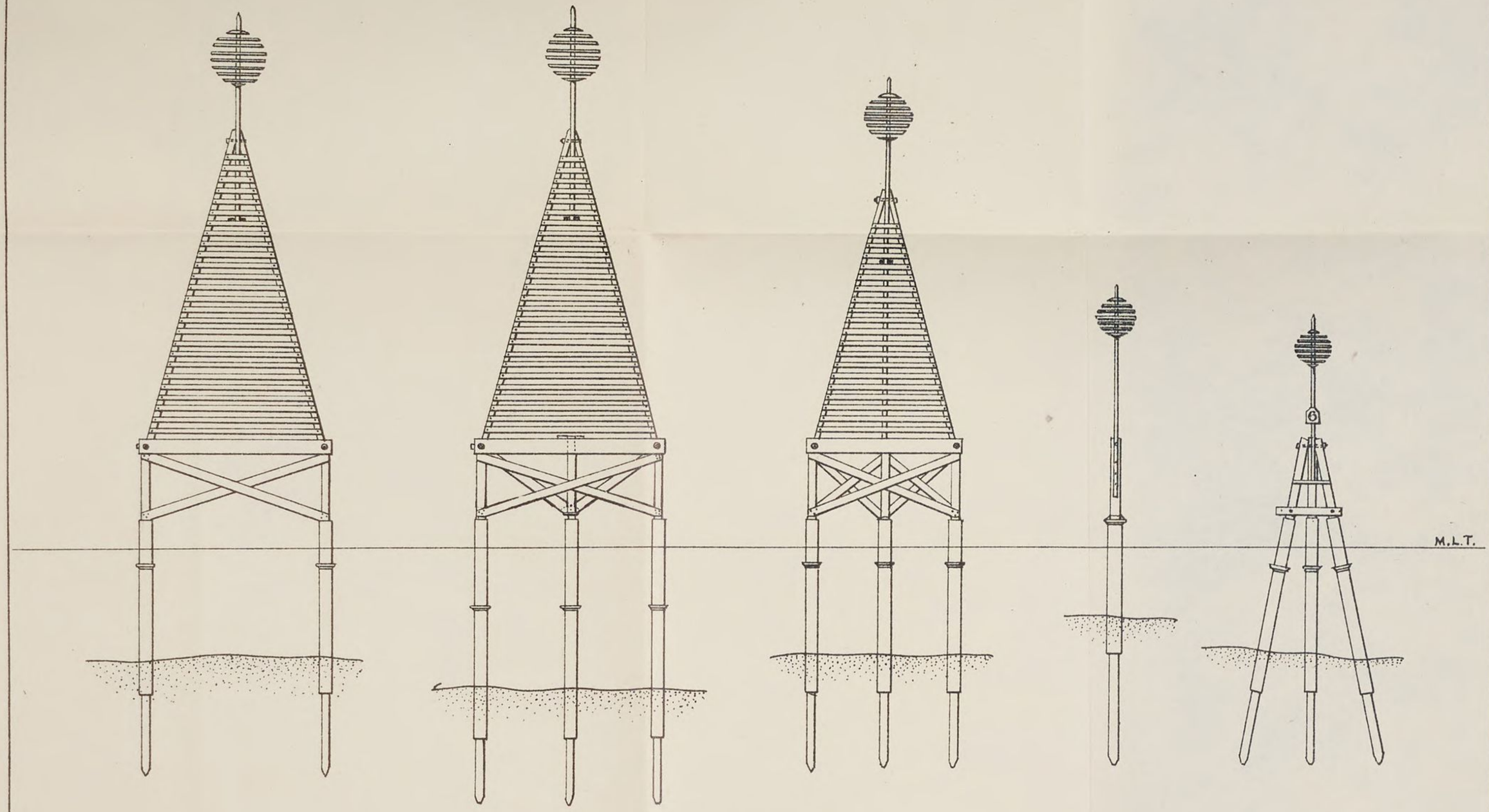
GENERAL CONSTRUCTION OF BEACONS

MARKING

SHIP CHANNEL
GALVESTON BAY, TEXAS

SCALE OF FEET

10' 5' 0 10' 20' 30' 40' 50'



GENERAL ELEVATION



HORIZONTAL SECTION AT M.L.T. SHOWING POSITION OF PILES

To accompany annual report June 30th 1890

Photo-Lith. by A. HOEN & CO., Balto., Md.

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The above force and plant continued through June, July, and August, 1889, when the schooner was transferred to Trinity River improvement, leaving the tug to finish up the incomplete work, which was accomplished during September and October, 1889.

GENERAL DESIGN OF BEACONS.

The beacons are constructed of timber piles 30 feet long, driven or pumped into the ground not less than 10 feet. The timber, to protect it from the ravages of the teredo, is encased in a cast-iron pipe, penetrating the ground not less than 3 feet and rising above M. L. T. not less than 2 feet, and the annular space between the timber and pipe is filled with hydraulic concrete. The piles thus driven and protected are properly braced and secured, and stand about 10 feet out of the water; on this, as a foundation, a slatted pyramid is erected surmounted by a signal pole and slatted ball, the whole standing out of the water from 40 to 45 feet high. For the second-class beacons, three piles are used, spaced 8 feet apart and drawn together at top, bolted, and surmounted with signal pole and ball. For the third-class beacons, a single pile is used with signal pole and ball. The second and third class stand from 20 to 25 feet out of the water.

SITUATION OF BEACONS.

Lower Beacon (L. B.) is on the east bank at the southern extremity of Ship Channel, off Gabion City, Bolivar Point; beacon H is off Pelican Island, and marks a shoal on the west of ship channel near its entrance; beacon L is on a shoal off Bolivar Point on the direct course to and from Galveston to the entrance of Ship Channel. Beacons Nos. 1, 2, 3, 4, 5, 6, 7, and 8, are on the east bank, and about 1 nautical mile apart from L. B. South Beacon (S. B.) is on the west bank at the southern approach to Red Fish Cut; beacon No. 9 is on the east bank of Red Fish Cut, at the intersection of Lower Bay and Red Fish Cut Range; Beacon No. 10 is on the east bank of Red Fish Cut at the intersection of Upper Bay and Red Fish Cut Range; North Beacon (N. B.) is in Upper Bay on west bank at the northern approach to Red Fish Cut. Beacons Nos. 11, 12, 13, 14, 15, and 16, are on the east bank about 1 nautical mile apart from beacon No. 10. Morgan's Beacon (M. B.) is on the west bank at the intersection of Upper Bay and Morgan's Cut Range, and marks the southern extremity of Morgan's Cut. The beacons on the east bank are 60 feet from edge of Cut, and have their signals colored red; those on west bank are colored black.

CASUALTIES.

After the completion of Beacons, No. 11 had to have the piles withdrawn and extra timber spiked on that part of the pile below ground to give it greater stability in the soft silt. No. 8 had the signal pole carried away, and No. 7 is slightly out of plumb from a barge coming in contact with it; this beacon will have to be stiffened, as it is in soft mud or silt and easily overturned.

In consideration of the probable surrender to the United States of Morgan's Canal and Cut, a few notes may be of interest about one of the highest observed freshets in the San Jacinto River and Buffalo Bayou and the strongest known current in the approach and through said canal.

The freshet occurred during the 3d, 4th, 5th, and 6th of April, 1890, and had the prevailing strong S. E. wind been blowing the country surrounding Morgan's Point would most probably have been inundated by the backing up of the Bay water with a high river. There was no local cause for the freshet as the weather was fine and wind light. The rise was occasioned by rains at the head waters of Buffalo Bayou and San Jacinto River. Twenty miles above Lynchburg, on the San Jacinto River, the rise was 22 feet above the normal. At Lynchburg 9 feet. At Clinton, on Buffalo Bayou, the water was over the wharf, and at Medway Warehouse, about half way between Lynchburg and Morgan's Point, the rise was 4 feet.

As observed at Morgan's Canal (by J. H. Warren, collector of tolls, stationed at Morgan's Point, at that time), the strong current commenced running on April 3, with drift from Buffalo Bayou and San Jacinto River on the morning of the 4th; the same morning some of the bulkhead on the east side of the canal began breaking up, and at 8 a. m. the instruments, etc., in the United States tide-house had to be removed, as the bulkhead all along the east side was going, and the tide-house piling showed signs of undermining. The last tide as recorded gave a height of 2′.8 above M. L. T. The water rose about two-tenths higher and stood at that height from four to five hours, then at 4 p. m. began to fall slightly. The last structure to disappear

on the east side was the tide-house, which finally collapsed, and went into the bay through the canal on the afternoon of the 5th.

The whole of the east and west bulkhead or revetment is practically gone. The worst scour or wash is north of station M. P. The banks caved most after the subsidence of water, when it had returned to its normal level and current. The caving had more of a sliding motion, the material being sandy and acting as quick-sand when saturated with water. The heavy chain (which is stretched across the canal to prevent navigation in case of refusal to pay toll) was slacked up and dropped to bottom of canal in 25 feet of water, so as not to retain drift. This chain, about 250 feet long, of $\frac{3}{4}$-inch iron, was raised by the strength of current from off the bottom to within 5 feet of surface of water. The failure of the bulkhead to protect the banks was faulty construction in having the piles too short and not properly braced—together with neglect in not keeping it in repair.

As there has been no survey of Ship Channel since June, 1889, no reliable data has been obtained as to its deterioration. A few soundings were taken in running up and down the bay on inspection of Trinity River and tide-houses, which show a slight filling up, but not to so great an extent this year as last, the silting up being slower in proportion to length of time from date of excavation.

Very respectfully, your obedient servant,

E. M. HARTRICK,
Assistant Engineer.

Maj. CHAS. J. ALLEN,
Corps of Engineers, U. S. A.

V 3.

IMPROVEMENT OF TRINITY RIVER, TEXAS.

The following description of this river and improvement is taken from the annual report of my predecessor in charge for 1889:

"The Trinity River empties into Galveston Bay through several mouths or passes, near its northeast extremity, about 35 miles from Galveston. The relative importance of the passes appears to have varied considerably. The one generally used by vessels of late years is the Middle Pass. The channel depth in the river immediately above the passes is 16 feet or more. The depth in the Middle Pass is 9 feet or more. Opposite the mouth of each of the passes is a bar, the depth upon the crest of that of the Middle Pass being now 3 feet 2 inches. The trade using the river is carried in sailing vessels which draw from 3 feet to 4 feet 8 inches. To accommodate them there should be a channel $5\frac{1}{2}$ to 6 feet deep.

It is stated upon page 539 of the Annual Report of the Chief of Engineers for 1871 that Pass A, or the Southeast Pass, was excavated by the Government in 1865 to facilitate the supply of fuel to the troops stationed in Galveston. This improvement was subsequently obliterated by natural causes. In 1880 a channel was dredged across the bar at the mouth of Middle Pass, its length being 4,800 feet, its average width 110 feet, and its least depth $5\frac{1}{2}$ feet, the amount of material removed being 47,300 cubic yards. (See Annual Report Chief of Engineers, 1881, page 1341.) This channel was also obliterated by natural causes. In the winter of 1884 and spring of 1885 a channel was again dredged through the bar at the mouth of Middle Pass to a least depth of 6 feet, its length being 3,750 feet. A wooden revetment was placed upon the west side of the channel for a length of 2,775 feet, and upon the east side for a length of 1,280 feet, of which the object was to prevent the excavated material deposited near by from flowing back into the cut. In my annual report for 1887 I stated that the channel had shoaled in some places; that additional dredging was needed, and that the revetments required repairs and extension. The cost of the necessary work was estimated at $25,000.

An appropriation of $12,500 for continuing the improvement having been made in the river and harbor act of Augnst 11, 1888, a survey was undertaken in April following to ascertain the condition of the bar and of the works executed for its improvement in 1884–'85. Upon the results of this survey the Annual Report of 1889 states as follows:

It was found that the channel, though not entirely obliterated, had shoaled considerably, and had a least depth at one point of only 3 feet 2 inches. The west revet-

ment is in fair condition for a length of about 1,800 feet from its up-stream end; the remaining 975 feet has been much damaged. The east revetment is in good condition for a length of 300 feet from its down-stream end; of the remainder only the piles remain. Evidence of the action of the teredo is found at the down-stream end of the west revetment, but for most of the distance the wood appears to have been protected by the presence of fresh-water.

The results obtained in 1885 could, perhaps, have been maintained by a small amount of annual dredging, though there are no data for estimating exactly what the amount of it would have been and what it would have cost. The new appropriation might be applied to again dredging out the channel, thus affording temporary relief, and to some repairs of the revetments. But in view of the irregularity with which appropriations are made it is believed that better results will in the end be obtained by building two parallel jetties, which shall concentrate the flow of the river and keep it at work upon the bar, whether there be funds available for continuing the improvement or not. Necessarily the jetties must be of a cheap form. It has accordingly been decided, with your approval, to build two parallel timber jetties, extending from the mouth of the Middle Pass across the bar to a depth of 6 feet in Galveston Bay. The west jetty is to follow the line of the present west revetment, and to embody as part of itself so much of that work as is serviceable. The interval between the two jetties is to be 275 feet. The form of construction is a continuous line of sheet-piling, driven 10 feet into the ground and projecting 4 feet above the water-surface, strengthened by a double row of stringers at top and another double row at the water-surface, which are in turn embraced between and bolted to stiff piles in pairs driven to a penetration of 15 feet, the interval between the pairs being 8 feet. The total length of the west jetty is to be 7,750 feet, and of the east jetty 7,600 feet. Low submerged dams or sills are to be placed across the two other principal passes to prevent their enlargement.

The total estimated cost of the two jetties and the two sills, including the removal of so much of the old east revetment as may remain after the completion of the new work, is $55,000. This is an increase of $30,000 above the estimates heretofore submitted, but the latter did not include the cost of maintenance. The present estimate is expected to create a channel 8 feet deep between the jetties, and to maintain it during the life of the timber, or say 8 years.

It was proposed to apply the available funds to the construction of the west jetty, beginning at the up-stream end and working down-stream as far as they would admit of. The present project, therefore, as modified in 1889, consists in an improvement by means of parallel jetties placed about 275 feet apart, of a total length of 15,350 feet, and the placing of low, submerged dams or sills across the other two principal passes. Estimated cost, $55,000.

Adding to this sum the amounts expended for dredging, etc., under former appropriations, the revised estimated cost of the improvement is brought up to $89,500.

Proposals for performing the work by contract under the appropriation of $12,500 by the act of August 11, 1888, were invited by public advertisement, and opened July 26, 1889. Benjamin F. Hutches, jr., being the lowest bidder, a contract for performance of the work was entered into with him on the 12th of August, the contract to be completed December 31, 1889.

The contractor commenced work on the 29th of August, but, owing to delays from breaking down of machinery, lack of material, bad weather and high water, and the demoralization of his labor by the unhealthful surroundings and high wages to be obtained at the neighboring port of Galveston in winter season, he only succeeded by the 31st of December in completing about 877 linear feet of jetty, or about 27 per cent. of the contract. An extension of time to include March 31, 1890, was granted him and he completed the contract on the 28th of that month. Total of completed work under the contract, 3,269 linear feet of timber jetty.

The survey, made after completion of the contract in March last, showed a slight deepening in the channel running parallel with the line of new jetty, an increase in depth on the bar of about 4 inches, and a

straightening of the channel, making the crossing of the bar easier than was the case before work of improvement commenced last year.

There remain to be constructed 4,481 linear feet of west jetty, 7,600 linear feet of east jetty, and two submerged dams or sills. For details of the work for the fiscal year reference is made to the report dated April 18, 1890, herewith, of Mr. E. M. Hartrick, assistant engineer, who had under his orders, as inspector, Mr. John Radermacher.

A special agent was employed during the year to keep a record of the commerce and tonnage of the river. Statistics compiled from his reports are herewith:

Amount expended to July 1, 1889	$34,535.97
Amount expended during the past fiscal year	12,419.60
Total	46,955.57

ABSTRACT OF APPROPRIATIONS MADE BY CONGRESS FOR IMPROVING TRINITY RIVER, TEXAS.

By act approved—	
June 18, 1878	$10,000
March 3, 1879	2,500
June 14, 1880	4,000
March 3, 1881	10,000
By act passed August 2, 1882	8,000
By act of August 11, 1888	12,500
Total	47,000

Of this amount the sum of $7,500 was expended in 1882 in removing obstructions between Liberty and mouth of the river.

The sum of $42,500 can be profitably expended during the fiscal year ending June 30, 1892, in completing the work.

The work is located in the collection district of Galveston. The nearest light-house is at Redfish Bar.

The amount of revenue collected at the port of Galveston for the fiscal year ending June 30, 1889, was $131,613.17.

Money statement.

July 1, 1889, amount available	$12,464.03
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	12,419.60
July 1, 1890, balance available	44.43
Amount appropriated by act of September 19, 1890	10,000.00
Amount available for fiscal year ending June 30, 1891	10,044.43
Amount (estimated) required for completion of existing project	32,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	32,500.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

Abstract of proposals for improving Trinity River, Texas, by constructing a timber jetty, received in response to advertisement dated June 26, 1889, and opened July 26, 1889, by Maj. O. H. Ernst, Corps of Engineers, U. S. Army, at Galveston, Texas.

No.	Name and address of bidder.	Price per linear foot of jetty.
1	Charles Clarke & Co., Galveston, Tex	$2.99
2	Isaac Heffron, Galveston, Tex	3.62
3	Benjamin F. Hutches, jr., Galveston, Tex	2.73
4	S. H. Merrill, Galveston, Tex	2.95
5	John Hogan, Mobile, Ala	4.36
6	J. L. Purple & Co., Washington, D. C	5.90
7	E. H. Sterrett & Co., Houston, Tex	4.00
8	B. J. Hughes, Galveston, Tex	2.89
9	Casey & Garthar, Galveston, Tex	3.42

Amount available for payment under this contract, $10,000.
No. 3, lowest. Acceptance recommended.
Nos. 6 and 9 were not accompanied by guaranties.

REPORT OF MR. E. M. HARTRICK, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., April 18, 1890.

SIR: I have the honor to submit the following report of operations during the fiscal year ending June 30, 1890, for improving Trinity River, Texas.

On the 27th of August, 1889, E. M. Hartrick, assistant engineer, was "assigned to the immediate charge of the improvement of Trinity River, Texas," for the prosecution of which work a contract dated August 12, 1889, had been entered into with Benjamin F. Hutches, jr., of Galveston. The work was to begin not later than the 1st of September, 1889, and to be completed on or before December 31, 1889.

The contractor notified the office on the 27th of August, 1889, that he was ready to commence work, and on the 28th assistant engineer, subinspector and contractor proceeded up the bay to the mouth of Trinity River, and on the 29th the work was laid out and starting point designated.

The schooner *A. Boden* was transferred on 1st of Sep'ember, 1889, from ship-channel improvement to Trinity River improvement, to be used as headquarters for the assisttant engineer and subinspector, as the contractor was not prepared with accommodations nor was there any suitable place adjacent to the work for quarters or subsisttence.

GENERAL OUTLINE OF WORK—FORM OF CONSTRUCTION.

It is proposed to build two timber jetties, one on the east and one on the west side of Middle Pass, extending from firm ground inside the bar to a depth of 6 feet in the bay outside the bar, the bar at present having a little over 3 feet of water at M. L. T.

The jetty recently completed consists of a pair of guide-piles set 8 feet apart, penetrating the ground at least 15 feet. Two pairs of horizontal string-pieces are placed, one at M. L. T., the other near top of piles. Between the string-pieces a continuous row of sheet-piling is driven, penetrating the ground not less than 10 feet and cut off to an even height of 4 feet above M. L. T. The string-pieces are bolted to each pair of guide-piles through the sheeting, with iron screw-bolts having the necessary nuts and washers.

From the first the work was delayed from the breaking down of machinery, lack of material, and later bad weather and high water. Also the labor was demoralized by the unhealthy surroundings, poor accommodations, and the high wages to be obtained at the port of Galveston in the winter season.

On account of the above casualties the contractor had to ask for an extension of three months from the 31st of December, 1889, to the 31st of March, 1890, which was granted, and the work finally completed on the 28th of March, 1890.

The material through which the piles were driven consisted at first of soft mud or silt interspersed with willow roots and drift logs, the best starting point to be found in that locality. Proceeding towards the Bay a crust of sand and shell from 2 to 5 feet was found, with a silt or soft-clay bottom: then further towards the bay, the crust with soft clay continuing as before, a stratum of comparatively hard material was found at from 8 to 10 feet below the bottom of bay, or 15 to 16 feet below M. L. T. A few drift-logs imbedded in the silt were encountered along the line of jetty,

causing a slight undulation in the alignment by reason of the guide-piles striking and obliquely gliding off the logs.

The survey after the completion of work did not develop any great change compared with previous surveys. This was to be expected, as there was not sufficient money to prolong the jetty over and past the bar. There was observed a greater height and slope of water on the river or east side of jetty, as compared with the outer or west side of jetty; also a slight deepening of the channel running parallel with the recent work, and an erosion on the river side of the island, on which Station C is located.

SUMMARY.

Contractor's force generally consisted of one foreman, one engineer of pile-driver, one cook, and eight laborers, with a plant of one schooner, one steam pile driver, one small barge, and four skiffs.

The work advanced as follows:

	Linear feet.
October, 1889	156
November, 1889	471
December, 1889	250
January, 1890	788
February, 1890	600
March, 1890	1,004
Total completed	3,269

Very respectfully, your obedient servant,

E. M. HARTRICK,
Assistant Engineer.

Maj. CHAS. J. ALLEN,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS OF TRINITY RIVER, TEXAS, FOR THE FISCAL YEAR ENDING JUNE 30, 1890.

[Compiled from reports rendered by Special Agent T. A. Kilgore, of Wallisville, Tex.]

Sailing vessels using the river, 33; length on deck, 32 to 80 feet; draught when loaded, 3 feet to 5 feet 6 inches; tonnage, 9 to 80 tons; trips made during the year, 1,221. Total tonnage, 16,887.

Amount and value of freight transported.

Articles.	Tons.	Approximate value.	Approximate freight charges.
Cotton	102	$10,233.24	$436.60
Lumber	10,906	30,649.15	12,201.80
General merchandise	719	5,492.50	1,611.50
Total	11,727	46,374.89	14,249.90

Decrease from last year, 452 tons.

Comparative statement of commercial statistics of Trinity River, Texas, for the fiscal years ending June 30, 1888, 1889, and 1890.

Year.	Vessels using the river.	Maximum length.	Maximum draught, loaded.		Maximum tonnage.	Number of trips made.	Total tonnage.	Transported.				Total value of cargoes.	Total freight charges.
								Cotton.	Lumber.	General merchandise.	Total weight.		
		Feet.	*Ft.*	*In.*	*Tons.*			*Tons.*	*Tons.*	*Tons.*	*Tons.*		
1888	32	65	4	8	32	1,217	15,958	226	11,863	855	12,944	$88,704	$17,027
1889	36	65	4	6	32	1,330	16,737	148	10,872	1,159	12,179	75,902	17,276
1890	33	80	5	6	80	1,221	16,887	102	10,906	719	11,727	46,374	14,249

V 4.

IMPROVEMENT OF BUFFALO BAYOU, TEXAS.

A survey of Buffalo Bayou and Galveston Bay to Bolivar Channel, with a view to improvement, was made in the winter of 1870–'71, in accordance with the provisions of section 2 of the river and harbor act of Congress approved July 11, 1870. The report of this survey is published in the Annual Report of the Chief of Engineers for 1871.

An examination of the bayou from Simms' Bayou to the mouth of White Oak Bayou at Houston was made in 1880 under section 2 of the river and harbor act approved June 14, 1880. The report upon this examination is published in the Annual Report of the Chief of Engineers for 1881.

It was estimated in this latter-named report that the cost of an improvement to give a channel 100 feet wide and 12 feet deep between the points named, by dredging and removal of snags and other obstructions, and including some necessary revetment, would be $385,299.75. Following this report was an appropriation of $25,000 by act approved March 3, 1881, for "improving Buffalo Bayou, Texas, to secure a channel of 100 feet."

A project, in accordance with the terms of the appropriation and in consonance with the report, was submitted April 25, 1881, and the subsequent appropriations have been applied in general furtherance of that project.

The following description of the bayou, its navigation, capacity for improvement, etc., is here reproduced from the Annual Report of 1887:

Buffalo Bayou is a tide-water stream, emptying into the San Jacinto River at Lynchburgh about 25 miles below Houston. It is one link in the water-way which connects Houston and Galveston and the Gulf of Mexico. White Oak and Simms' bayous are two of its tributaries, the first entering it at Houston, and the second at a point 11 miles below the first. The ultimate object of the improvement, as projected in 1880, is to secure a channel 12 feet deep and 100 feet wide, as in the case of the work in Galveston Bay, the aim being to admit sea-going ships to Houston. Below the mouth of Simms' bayou these dimensions are found in nature. It is between White Oak and Simms' bayous that improvement is required. The banks here are high and generally stable, though occasionally subject to land slides. The surface width is generally greater than 100 feet, but there are some exceptions to this rule. The depth in the center of the channel is usually 9 feet or more at ordinary tides but there are occasional shoals upon which as little as 6 feet is found, and during "northers" the surface is sometimes lowered several feet. At some some points navigation is obstructed by the sharpness of the bends. It is endangered also by sunken logs and stumps in the bed of the stream and by overhanging trees upon the banks.

There is upon the bayou a large and important traffic, carried on principally in barges towed by tugs. The tugs draw 7 feet or less, and the barges, when fully loaded, draw about 5 feet. While this trade can be economically carried on with less dimensions of channel than those contemplated in the project, it is greatly benefited by the partial improvements which may be made in the earlier stages of the work. Useful results from the expenditure of the appropriations can be obtained in advance of the full completion of the work. A depth of 9 feet at ordinary tides will generally insure a sufficient depth during "northers". The enlargement of the channel and the removal of snags and overhanging trees, and the easement of bends, is of direct and immediate benefit to commerce. The method of conducting the work therefore differs from that followed in the case of the Ship Channel in Galveston Bay. Instead of excavating a portion of the channel to its full dimensions, those obstructions which impede the present navigation are removed first. A new supply of sunken logs is found annually, and considerable shoaling, from surface wash, also occurs annually.

* * * * * * *

It is reasonably certain that the amount estimated for the completion of the present project, which has heretofore accompanied the annual reports upon this work, will not be sufficient for that purpose. To make a new estimate would involve a resurvey, which is expensive. Moreover, it is impossible to make an accurate estimate of

what the final cost will be, if the work be prosecuted as heretofore, under small and irregular appropriations.

* * * * * * *

The Buffalo Bayou Ship Channel Company have acquired rights from the State of Texas, in connection with this stream, as in the case of the Ship Channel in Galveston Bay.

* * * * * * *

Under this charter the company seems to have the right to continue the improvement, taking it at any stage short of that where vessels drawing 9 feet can visit Houston, and then having made the stream navigable for such vessels, charge tolls upon all vessels, however small their draught. Although the company has shown no disposition to take advantage of this right, it is submitted that the right should be extinguished. Proper compensations should, of course, be made.

The last appropriation for this improvement, viz, that of $25,000 by act of August 11, 1888, was applied to dredging, and removal of stumps, logs, etc., from the bed and banks between White Oak Bayou and a point 6 miles below. The contract under which this work was done was to have been completed June 30, 1889, but as it was evident that it could not be so completed an extension of time to include July 31, 1889, was granted the contractor; the work done under that extension consisted, principally, in easing the sharpness of Bend No. 3, 6 miles below White Oak Bayou.

The work performed during the past fiscal year, under the contract named, is represented by the following quantities:

Cubic yards of material dredged and removed	6,651
Cubic feet of logs removed	950
Stumps removed	112

Assistant Engineer R. B. Talfor, was in local charge of the work throughout the period embraced by the contract.

The trade of the bayou is principally carried on by the Houston Direct Navigation Company with tugs and barges. A statement of the freight carried by them during the past fiscal year is appended. Many small vessels also visit the bayou. To ascertain the extent of this trade a special agent was employed throughout the year to keep a daily record of all such vessels. The shipments of cotton down the bayou from Houston to be loaded onto sea-going vessels at Galveston, are immense. The number of tons thus shipped during the past fiscal year was 66,852 as against 41,227 for the year preceding.

While the appropriations thus far made from time to time for this improvement have aggregated but about 37 per cent. of the original estimated cost of the improvement, and while the work done under those appropriations has in consequence not secured the full depth or width of channel required, the improvements thus far effected have so greatly facilitated navigation that further and regular appropriations for the improvement of this important stream can justly be asked for. In view of the probable increase in the commerce of Buffalo Bayou, some of those interested in its navigation favor an improved channel of greater dimensions than the present project provides for. The practicability and cost of such increased channel can only be decided by a full and complete survey. Before the work for the fiscal year ending June 30, 1889, was begun, the available depth for the portion of the stream afterwards worked over during that year, was from 5½ to 7 feet, and the width of the channel for that depth was from 30 to 60 feet. These dimensions were increased during that year to a minimum depth of 9½ feet with a width of from 40 to 80 feet. The stream has been visited by heavy freshets during the past spring, and it is probable that the advent of low water will disclose some deterioration in dredged depths as well as the presence of snags brought in by the freshets.

The bayou has not received a full survey or examination with a view to rendering complete estimates of cost of finishing an improvement since

1880. In consequence, the original (old) estimate of cost is retained in this report, viz, $385,299.75.

Aggregate amount appropriated to July 1, 1890	$143,750.00
Expended under the project to July 1, 1889	138,393.82
Expended during the past fiscal year	5,297.91
Total expended under the project	143,691.73

It is estimated that the sum of $50,000 can be profitably expended during the fiscal year ending June 30, 1892, in continuing the improvement by again going over the ground heretofore worked over, widening the water-way where the width is less than 100 feet, and where the cost of widening is not excessive, and where the banks will bear such widening without danger of sliding, in deepening the channel where it is less than 9 feet at mean low tide, by dredging, in easing the sharpness of bends by cutting off the points by scraping and dredging, and in removing such sunken logs, stumps, etc., from the bed, and such overhanging trees from the banks as may interfere with navigation; all the work being located between White Oak and Simms's bayous.

The work is located in the collection district of Galveston. The nearest lighthouses are those in Galveston Bay. The amount of revenue collected at the port of Galveston for the fiscal year ending June 30, 1890, is $131,613.17.

ABSTRACT OF APPROPRIATIONS MADE BY CONGRESS FOR IMPROVING BUFFALO BAYOU, TEXAS.

By act approved March 3, 1881	$25,000
By act passed August 2, 1882	50,000
By act approved July 5, 1884	25,000
By act approved August 5, 1886	18,750
By act of August 11, 1888	25,000
Total	143,750

Money statement.

July 1, 1889, amount available	*$719.27
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889, and exclusive of payments made on contracts in force July 1, 1889	661.00
July 1, 1890, balance available	58.27
Amount appropriated by act of September 19, 1890	25,000.00
Amount available for fiscal year ending June 30, 1891	25,058.27
Amount (estimated) required for completion of existing project	216,549.70
Amount that can be profitably expended in fiscal year ending June 30, 1892	50,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS OF BUFFALO BAYOU, TEXAS, FOR FISCAL YEAR ENDING JUNE 30, 1890.

[Compiled from reports of Special Agent L. F. Allien, of Houston, Texas, and L. Megget, esq., secretary of the Houston Direct Navigation Company.]

Number of vessels using the bayou.—Character: Nineteen barges, 122 feet to 173 feet long, 5 feet draught; tonnage, 115 to 254 tons each. Towed by six tugs, 54 feet to

*On July 1, 1889, the amount to complete the contract then in force was estimated to be $4,233.44; but it actually required $4,636.91. Hence the amount available by July 1, 1889, is reduced by $403.47.

94 feet long, 4 feet 6 inches draught; 14 to 105 tons each. Forty-two schooners and sloops, from 20 to 83 feet long, 3 feet to 6 feet draught; tonnage, 3 to 70 tons.

Trips made during the year..... 617
Total tonnage of sailing vessels..... 13,870

Tonnage of barges and tugs not reported.

Amount and value of freight transported.

Articles.	Tons.	Value, approximate.	Freight charges, approximate.
Cotton (243,100 bales)	66,852	$13,370,500.00	$121,550.00
Cotton-seed cake and meal	19,199	342,840.00	17,142.00
Coal	2,970	18,564.00	2,652,00
Iron and steel	1,278	63,075.20	1,016.00
Lumber and shingles	512	8,653.36	1,798.48
General merchandise	5,423	77,133.64	10,557.14
Total	96,234	13,880,766.20	154,715.62

Increase over iast year, 35,684 tons.

Comparative statement of commercial statistics of Buffalo Bayou, Texas, for the fiscal years ending June 30, 1888, 1889, *and* 1890.

Years.	Vessels using bayou.			Maximum length.	Maximum draught	Maximum tonnage.	Trips made.
	Schooners.	Tugboats.	Barges.				
				Feet.	*Feet.*	*Tons.*	
1888	62	7	20	173	8	254	920
1889	38	7	19	173	7	254	735
1890	42	7	19	173	7	254	617

Years.	Transported.						Total weight.	Total value.	Total freight charges.
	Cotton.	Cotton-seed cake.	Coal.	Lumber.	Iron.	General merchandise.			
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*		
1888	26,692	9,959	4,320	2,765	1,509	4,596	49,841	$5,132,323	$94,960
1889	41,227	12,628	3,456	1,221	1,120	898	60,550	7,617,380	98,794
1890	66,852	19,199	2,970	512	1,278	5,423	96,234	13,880,766	154,715

V 5.

IMPROVEMENT OF ARANSAS PASS AND BAY, UP TO ROCKPORT AND CORPUS CHRISTI, TEXAS.

A description of this locality and of the works undertaken for its improvement was given in the Annual Report for 1888. The project for improvement was adopted in 1879 and modified in 1887, the object being to fix the position of the pass by means of revetment at the head of Mustang Island and to provide, by means of jetties, a navigable channel at least 20 feet deep through the bar. In its natural state the pass was moving bodily in a southwesterly direction at the rate of about 260 feet per year and the channel depth over the bar varied from 7 feet to 9½ feet.

During the past fiscal year the revetment at the head of Mustang Island and the United States engineer property at the pass were cared for. Tide records were kept and plotted. Records of the trade of the pass were kept by special agents employed for the purpose; one at Corpus Christi and one at Rockport. Commercial statistics compiled from these records, and the statement of the United States customs collector at the port of Corpus Christi are hereto appended. The last Annual Report estimated $1,471,293.72 as the sum necessary for completing the existing project. The balance of funds ($44,319.59) available at the beginning of the present fiscal year was too small to warrant commencement of work upon the jetties.

Congress, by an act approved May 12, 1890, having granted to the Aransas Pass Harbor Company the right, under certain conditions, to improve the navigation of the pass and to utilize, in such improvement, the existing United States works at the pass, the United States engineer property at that point was disposed of during the month of June. The tools, boats, etc., were sold at public sale and the proceeds covered into the Treasury according to regulations. The instruments were transferred to the United States engineer office at Galveston. Under authority from the Department, June 28, 1890, this work was dropped from the list of improvements in charge of this office. The record is closed with this report.

Expended under the project for this work, to July 1, 1889, $546,869.34, including $9,938.93 contributed in 1883 by citizens of Rockport and Corpus Christi, which resulted in fixing the position of the pass. Expended during the fiscal year ending June 30, 1890, $3,547.24. Total expended, $550,416.58.

ABSTRACT OF APPROPRIATIONS MADE BY CONGRESS FOR IMPROVING ARANSAS PASS AND BAY, TEXAS.

By act approved—	
March 3, 1879	$35,000
June 14, 1880	65,000
March 3, 1881	80,000
By act passed August 2, 1882	100,000
By act approved July 5, 1884	100,000
By act approved August 5, 1886	101,250
By act of August 11, 1888	100,000
Total	581,250

The work is located in the collection district of Corpus Christi, Tex. The nearest light-house is upon Harbor Island, just inside the entrance. The amount of revenue collected at Corpus Christi during the fiscal year ending June 30, 1890, was $25,385.36.

Money statement.

July 1, 1889, amount available	$44,319.59
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	3,547.24
July 1, 1890, balance available	40,772.35

COMMERCIAL STATISTICS OF ARANSAS PASS, TEXAS, FOR THE FISCAL YEAR ENDING JUNE 30, 1890.

[Compiled from reports rendered by Special Agent Thomas Allen, of Corpus Christi, Tex., and Special Agent John McBride, of Rockport, Tex.]

Sailing-vessels using the pass, 38; length on deck, 41 to 99 feet; draught when loaded, 4 feet 6 inches to 7 feet; tonnage, 13 to 81 tons each; trips made during the year, 296; total tonnage, 10,904.

Amount and value of freight transported.

Articles.	Tons.	Approximate value.	Approximate freight charges.
Lumber and shingles	9,329	$81,181.00	$27,562.97
Hides, wool etc	246	49,192.03	651.32
General merchandise	151	5,080.00	242.00
Total	9,726	135,453.03	28,456.29

Decrease from last year, 156 tons.

Comparative statement of commercial statistics of Aransas Pass, Texas, for the fiscal years ending June 30, 1888, 1889, and 1890.

Year.	Vessels using pass.	Maximum length.	Maximum draught.	Maximum tonnage.	Trips made.	Total tonnage.
		Feet.	*Feet.*	*Tons.*	*Tons.*	*Tons.*
1888	44	241	10	678	389	59,492
1889	28	219	8	537	245	13,895
1890	38	99	7	81	296	10,904

Year.	Transported.					Total value.	Total freight charges.	Revenue collected.
	Cotton.	Coal.	Lumber.	General merchandise.	Total.			
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*			
1888	16	795	16,967	3,282	21,060	$559,424	$56,656	$22,240.00
1889	61	558	8,368	895	9,882	129,443	30,403	23,561.00
1890	.....	.....	8,329	397	9,726	135,453	28,456	25,385.36

V 6.

IMPROVEMENT OF HARBOR AT BRAZOS SANTIAGO, TEXAS.

The work of construction for improvement of this harbor was suspended in October, 1884. The subject of improvement of the harbor was referred by the Chief of Engineers, under date of December 8, 1885, to the Board of Engineers for report. The Board called for certain information which involved a resurvey of the harbor and other investigations. A surveying party left Galveston on the 24th of June, 1887, to procure the desired information, completing the survey early in August following. The results of the survey were reported under date of September 29, 1887. The report showed that the work (south jetty) completed in 1884 had practically disappeared. The project under which that jetty had been built contemplated the construction of two parallel jetties, as follows: The south jetty (Brazos Island Jetty) to be 3,630 feet long, and the north jetty (Padre Island Jetty) to be 2,940 feet; the direction of the jetties to be in prolongation of the pass, the width between them to be about the same as that of the narrowest part of the pass, viz, 1,500 feet; estimated cost of the north jetty, about $130,000; estimated cost of the south jetty, about $190,000. In addition, it had been proposed to construct a dam from Point Isabel to Brazos Island to increase the depth of water on the bar and in the channel to Point Isabel by preventing the flow towards Boca Chica.

Approval had been given to so much of the project as covered the construction of the south jetty. For information in detail as to the condition of the work and cost of further improvement, reference is here made to the report of September 29, 1887, and to that of the Board of Engineers, both contained in Appendix T to the Annual Report of the Chief of Engineers for 1888, pages 1322–1330 and pages 1299 and 1300.

From the best information attained by the survey the cost of an improvement to consist of two parallel jetties placed about 1,100 feet apart was estimated at not less than $1,130,000, and it was also estimated in the Annual Report for 1888 that the appropriation necessary for carrying on that work (should it be ordered) for the fiscal year ending June 30, 1890, should not be less than $600,000. The total of expenditures under appropriations at the date of rendering the estimate of $1,130,000 was $188,590.23, so that the revised estimate of cost of the improvement, counting from the commencement of work, was thus brought up to $1,318,590.23.

The total of appropriations, to include the last one, that of $25,000 by act of August 11, 1888, is $247,500. The expenditures since work ceased in 1884 have amounted to $4,654.87 in making survey and in contingencies, including in the latter the cost of collecting commercial statistics of the port.

No work for improvement was done during the past fiscal year, the amount of money available having been too small to warrant commencing it. A special agent was employed during the year to keep a daily record of all incoming and outgoing trade. Commercial statistics compiled from this record are hereto appended. It will be seen that the trade of the port is comparatively light. Comparison of this with records of last year shows an increase of tonnage of 4,732 tons.

The conclusion that not less than $600,000 should be available before undertaking further work is here concurred in, though it is not asserted that the amount of commerce to be benefited justifies such an expenditure at this time. And it is respectfully suggested that if the importance of the port be not considered sufficient to justify so large an appropriation the improvement be deferred for the present. There remains in round numbers $550,000 as the sum that should be appropriated for the fiscal year ending June 30, 1892, in case Congress orders the improvement indicated.

Original estimated cost of the work as revised in 1888	$1,318,590.23
Aggregate amount appropriated to July 1, 1890	247,500.00
Amount expended to July 1, 1889, including outstanding liabilities	188,650.23
Amount expended during the past fiscal year	898.36
Total expended	189,548.59

In addition there was appropriated in 1878 $6,000, which was applied to removing a wreck.

The work is located in the collection district of Brownsville. The nearest light-house is the Brazos Santiago light-house on Padre Island. The amount of revenue collected at the port of Brownsville during the fiscal year ending June 30, 1890, was $37,990.59.

ABSTRACT OF APPROPRIATIONS MADE BY CONGRESS FOR IMPROVING HARBOR AT BRAZOS SANTIAGO, TEXAS.

By act approved—	
June 14, 1880	$25,000
March 3, 1881	75,000
By act passed August 2, 1882	60,000
By act approved—	
July 5, 1884	25,000
August 5, 1886	37,500
By act of August 11, 1888	25,000
Total	247,500

Money statement.

July 1, 1889, amount available		$58,849.77
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$668.36	
July 1, 1890, outstanding liabilities	230.00	
		898.36
July 1, 1890, balance available		57,951.41
Amount (estimated) required for completion of existing project		1,071,090.23
Amount that can be profitably expended in fiscal year ending June 30, 1882		550,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

COMMERCIAL STATISTICS OF BRAZOS SANTIAGO, TEXAS, FOR THE FISCAL YEAR ENDING JUNE 30, 1890.

[Compiled from reports rendered by Special Agent E. J. Kenedy, of Isabel, Tex.]

Vessels using the harbor, 20; character, 4 steamers and 16 sailing vessels. Length on deck, 44 to 219 feet; draught, 2 feet 4 inches to 9 feet 3 inches. Tonnage, 18 to 717 tons; trips made during the year, 170; total tonnage, 40,641.

Amount and value of freight transported.

Articles.	Tons.	Approximate value.	Approximate freight charges.
Cotton	80	$4,400	$310
Wool and hides	4,153	220,730	19,642
Lumber	2,938	36,844	13,595
General merchandise	14,844	807,215	95,585
Total	22,015	1,069,189	129,132

Increase over last year, 4,732 tons.

Comparative statement of commercial statistics of Brazos Santiago Harbor, Texas, for the fiscal years ending June 30, 1888, 1889, and 1890.

Year.	Vessels using harbor.	Maximum length.	Maximum draught.	Maximum tonnage.	Trips made.	Total tonnage.
		Feet.	*Feet.*	*Tons.*		*Tons.*
1888	12	241	10	678	126	44,741
1889	18	241	10	678	158	46,319
1890	20	219	9	717	170	40,641

Year.	Transported.				Total weight.	Total value.	Total freight charges.	Revenue collected.
	Cotton.	Wool and hides.	Lumber.	General merchandise.				
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*			
1888	.....	2,925	2,324	9,867	15,116	$737,472	$83,541	$31,625.00
1889	130	3,080	3,188	10,885	17,283	820,315	78,140	20,338.00
1890	80	4,153	2,938	14,844	22,015	1,069,189	129,132	37,990.59

[Information furnished by George More, special deputy collector of the port of Brownsville, Tex.]

Amount of revenue collected during the fiscal year ending June 30, 1890..	$37,990.59
	Tonnage.
Steam-vessels cleared, 32	19,715.50
Sailing vessels cleared, 1	69.42
Steam-vessels entered, 32	19,715.50
Total	39,500.42

V 7.

PRELIMINARY EXAMINATION FOR REMOVAL OF BAR AT MOUTH OF CEDAR BAYOU WHERE IT EMPTIES INTO GALVESTON BAY, TEXAS.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., January 25, 1889.

SIR: The river and harbor act of August 11, 1888, provided for a survey for "Removal of bar at mouth of Cedar Bayou where it empties into Galveston Bay," Texas, if after preliminary examination by a local engineer the stream should, in the opinion of the Chief of Engineers, be worthy of improvement by the General Government.

A similar provision was contained in the river and harbor act of August 5, 1886, and was the subject of my report dated January 10, 1887, published in House Ex. Doc. No. 58, Fiftieth Congress, first session, page 108. In that report the value of the trade to be benefited by the proposed improvement was stated to be about $200,000 per year, and it was estimated that a saving in freight rates would result of something over $2,000 per year, while the annual cost of maintenance, including interest upon the sum to be applied to the original excavation, would be something less than $2,000 per year. The question, was the stream worthy of improvement, as a bare proposition, was therefore answered in the affirmative. Whether it was worthy of improvement by the General Government at that time, however, appeared to me to involve a question of general public policy independent of the merits of this particular case, and I thought it proper when stating that Cedar Bayou was worthy of improvement, to state at the same time that I did not recommend its improvement by the General Government. I am informed that in response to that report an item appropriating money for the work has been placed in the river and harbor bill now before Congress. Any further discussion by me of the general public policy involved being thus silenced, I now have the honor to report that the stream is worthy of improvement.

For the preparation of a plan of improvement and an accurate estimate of cost a survey is necessary, the cost of which is estimated at about $500.

Very respectfully, your obedient servant,

O. H. ERNST,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

SURVEY FOR REMOVAL OF BAR AT MOUTH OF CEDAR BAYOU WHERE IT EMPTIES INTO GALVESTON BAY, TEXAS.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., December 14, 1889.

GENERAL: I have the honor to submit the following report of a survey with a view to presenting plan and estimate of cost for "Removal of bar at mouth of Cedar Bayou where it empties into Galveston Bay," made in accordance with the requirements of sections 13 and 14 of the river and harbor act of Congress of August 11, 1888.

The surveying party, in charge of Assistant Engineer R. B. Talfor, took the field on the 14th of November, under directions from Lieut. Wm. C. Langfitt, Corps of Engineers, and completed the field work about the 22d.

The sum of $500 had been allotted for the survey and examination, which covered a large area of the bar at the mouth of the bayou and extended nearly 2 miles up the latter.

Cedar Bayou discharges into the northwest corner of Galveston Bay at a point about 1½ miles below the mouth of San Jacinto River and distant about 28½ miles from Galveston. The bayou has a general width, near its mouth, of 250 feet, and a depth just inside the bar, of about 7 feet.

The bar at the mouth of the bayou is composed of a mixture of clay, mud, sand, and shells, and its ruling depth, at mean low tide, is 3 feet.

The value of the commerce carried over the bar amounts to about $113,000 per annum, the freight charges upon which now exceed $18,000 annually. The freight, consisting of brick, cotton, cattle, etc., is carried in eighteen vessels having an aggregate tonnage of 483 tons. To accommodate this commerce a depth of 5 feet is needed, and it is claimed that such depth would result in reducing freight charges by 25 per cent. to 33⅓ per cent.

The accompanying tracing shows several lines projected to afford 5 to 6 feet depth of water, the estimated cost of improvement varying from $18,150 to $51,700.

It is believed that sufficient relief can be afforded the commerce of the bayou by dredging to give a depth of 5 feet at mean low tide, on the line A H as indicated on the tracing. The bottom width of the cut to be 100 feet, side slopes about one-third, and the cut to be protected on each side from action of waves and currents by walls or revetment which will, at the same time, serve to maintain dredge spoil in place. The north wall or revetment to extend from Ashe's Point, and the south revetment from the point at the mouth of the bayou, as indicated approximately on the tracing.

The only material for revetment that, as regards cost, seems to be admissible, is timber. It appears, from statements made to this office, that the fresh water from the bayou and from San Jacinto River tempers the salt water of the bay sufficiently at the mouth of the bayou, excepting during severe drought, to weaken the activity of the teredo and to thus make it probable that timber revetment can be relied upon, in this particular locality, to last for a number of years.

Estimate of cost for an improvement on line A H to give 5 feet of water.

31,000 cubic yards of excavation, at 25 cents	$7,750
North revetment, 2,000 linear feet; south revetment, 3,000 linear feet; total, 5,000 linear feet, at $1.75 per foot	8,750
Total	16,500
Add for contingencies 10 per cent	1,650
Total cost	18,150

And this sum can be profitably expended upon the improvement during one fiscal year, should the improvement be ordered by Congress.

Some additional dredging may occasionally be required at the entrance to, and in, the channel in order to maintain the depth.

The report of Assistant Engineer R. B. Talfor, containing statistics and other information in detail, is herewith.

Very respectfully, your obedient servant,

CHAS. J. ALLEN,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. R. B. TALFOR, ASSISTANT ENGINEER.

UNITED STATES ENGINEER, OFFICE,
Galveston, Tex., December 13, 1889.

SIR: I have the honor to make the following report of the survey of Cedar Bayou Bar.

In accordance with instructions contained in letter of November 4, I left Galveston November 14 and arrived off Cedar Bayou same evening, when the ground was looked over and the work of erecting signal stations commenced.

Two stations were established, one on Cedar Bayou Point and the other in the bay, about 1 mile from the mouth of the bayou. These were called respectfully, "N" and "M," and were located by triangulation from stations "M. P." "C. L. H" and "M. K." of the ship-channel survey which stations it was found necessary to renovate.

The Bayou, as far as examined, has a tortuous course and is connected at several points with broad sheets of shoal water. The banks are composed of clay and are, as a rule, low and nearly perpendicular above water. The country on each side is partially timbered.

The shore-line facing the bay was located by sextant angles. The topography of the bayou for a distance of about 7,000 feet was taken by transit and stadia rod. (To station 22 on chart.) Beyond this for a distance of 4,000 feet a reconnaissance was made with a prismatic compass—the distances being estimated.

The soundings were made from the schooner or yawl-boat, as found most convenient, and were located in the usual manner by time and simultaneous sextant angles. As during the whole time of survey the tide was from one-half to one and one-half feet below the plane of mean low tide of the place, it was found impossible to carry the soundings over shoals.

Two gauges were put up; one in the bay at station "M" and one in the bayou, near its mouth, and half-hourly readings recorded during the time of sounding. These gauges were subsequently connected with the established mean low tide of the gauge at Morgan's Point by simultaneous readings at both places, covering a period of two days.

Proposed improvements for a 5 *and* 6 *foot channel respectively.*

(1) Line A B, with a cut 5 feet deep and bottom width of 100 feet, following the line of deepest water from the mouth of the bayou to the 5-foot contour in the bay, and protected on the west side by a pile and plank revetment to prevent the dredged channel from deterioration of the cross currents of the San Jacinto River flowing east and south of Clopper's Bar.

Dredging 39,000 cubic yards, at 25 cents per yard	$9,750
5,200 linear feet of revetment, at $1.75 per foot	9,100
	18,850
Add 10 per cent. for contingencies	1,885
Total for a 5-foot channel	20,735
Dredging from the 5-foot depth to the 6-foot contour:	
12,000 cubic yards, at 25 cents per cubic yard	3,000
Add 10 per cent. for contingencies	300
Total for a 6-foot channel	24,035

(2) Line C D by a canal from the bayou south through "Mosquit Knoll," with a bottom width of 50 feet, slopes 3 to 1:		
Dredging 190,000 cubic yards, at 20 cents per yard		$38,000
1,500 feet of sheet-piling at east and west side at mouth of canal; total 3,000 feet, at $3		9,000
		47,000
Add 10 per cent. for contingencies		4,700
Total for a 6-foot channel		51,700
(3) Line E F by a cut through Cedar Bayou Point connecting with line A B to a 5-foot depth:		
Dredging 23,000 cubic yards, at 20 cents per yard		4,600
Dredging 40,000 cubic yards in bay, at 25 cents per yard		10,000
4,000 feet of revetment, at $1.75 per foot		7,000
		21,600
Add 10 per cent. for contingencies		2,160
To the 6-foot depth on line A B, dredging		3,000
Total for a 6-foot channel		26,760
(4) On line A. H.:		
Dredging 31,000 cubic yards, at 25 cents per cubic yard		7,750
North revetment, 2,000 feet; south revetment, 3,000 feet; total, 5,000 feet, at $1.75 per foot		8,750
		16,500
Add 10 per cent. for contingencies		1,650
Total for a 5-foot channel		18,150

COMMERCIAL STATISTICS.

The value of the commerce carried over Cedar Bayou Bar amounts to about $108,250 per annum as follows:

Article.	Quantity.	Approximate value.	Freight charges.
Brick, number	7,000,000	$63,000.00	$12,250.00
Beef cattle, head	2,000	24,000.00	4,000.00
Cotton, bales	200	9,000.00	200.00
Chickens, dozens	750	2,250.00	375.00
Eggs, do	30,000	5,000 00	37.50
Hides, hay, butter, etc., pounds	.....	2,500.00	875.00
Wood, oak, cords	500	2,500.00	875.00
Total	.....	108,250.00	18,612.50

This freight is carried in 18 vessels with an aggregate tonnage of 483 tons, their average draught when loaded being about 3½ feet. The information from which this table was compiled was furnished by Mr. R. A. Milam, owner of one of the Cedar Bayou brick-yards, who states that the present trade of Cedar Bayou could be done with one-half of the number of vessels at present employed if the depth across the bar were increased from 1 to 3 feet. This statement has been corroborated by several masters of vessels. Mr. Milam further states that he believes that with increase of depth freight charges will be reduced 25 to 33⅓ per cent.

In conclusion, would state that, owing to the small allotment ($500) for this survey, much valuable information, such as borings, current measurement, etc., could not be obtained. My acknowledgments are due to Messrs. Gerald Bagnall, assistant engineer, and H. J. Condron for valuable assistance in the conduct of the survey and estimates.

Very respectfully, your obedient servant,

R. B. TALFOR,
Assistant Engineer.

Maj. CHAS. J. ALLEN,
Corps of Engineers, U. S. A.

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